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ABSTRACT

A void exists between the rapid growth of post-high school trade and technical education and the development of educational management tools for that area. Hoping to help fill this void, this research effort concentrated on the development of psychometric instruments useful in measuring achievements. Trade and technical areas involved in the study include electrical installation and maintenance, machinists, electronics, and data processing. The tests developed for these and other areas provide objective, reliable, and valid indices of the level of proficiency achieved by students and will provide teachers, administrators, and researchers with a tool for more effective management of their programs. Although the tests are not included in this report for security reasons, the information does include (1) detailed test specifications, (2) descriptions of the samples, (3) reliability of subtests, (4) intercorrelations of subtests, (5) correlations with other standardized measures of achievement, norms, and other psychometric data. Also for each curriculum, detailed information is presented on the test specifications, sample, and psychometric characteristics of both the experimental and final forms of the test. (Author/JS)

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THE DEVELOPMENT OF ACHIEVEMENT MEASURES FOR TRADE AND TECHNICAL EDUCATION

Thomas S. Baldwin
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Urbana, Illinois

September 1970

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The success of any major research undertaking to a great extent depends upon the availability of competent and motivated staff. While the research reported on here is no exception to this rule, it is exceptional in that few projects have enjoyed the benefits of such a highly motivated and competent staff. To the extent that this project makes a contribution to vocational and technical education it has been through the efforts of the individuals listed below. All of them were formally affiliated with the project and generously contributed their time, advice, and scholarly assistance to make the project possible.

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Thomas S. Baldwin, Ph.D.
Principal Investigator

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CHAPTER I

INTRODUCTION

No segment of education has grown so rapidly in the last few decades as that representing the post high school sub-baccalaureate level. This segment of education, which encompasses many different types of programs offered in junior colleges, community colleges, technical institutes, etc., is widely recognized as being one of the most appropriate solutions to many of our societal problems. Regardless of the type of institution operating at this level, one common thread found in virtually all of them is emphasis on trade and technical education. This widespread emphasis is implicit recognition of the fact that such programs have great potential for the economic growth of this country.

While this nationwide emphasis on post high school trade and technical education is fulfilling an important need, the maximum utility of the system has not been achieved by the very fact of its rapid growth. Many of the "tools" of educational management that are well known and widely used at the elementary, secondary, and college level have evolved with these levels of education over a long period of time. The rapid growth of post high school trade and technical education, however, has resulted in a lag in the development of educational management tools appropriate for that level.

It is toward the development of one such tool, standardized achievement tests, that this research was directed. The widespread use in other segments of education of standardized psychometric instruments for assessing student potential, interests, achievement, etc., is widely known. One has only to look at the phenomenal growth of organizations such as Educational Testing Service over the last twenty-five years to realize the heavy reliance that educators place on psychometric instruments for use in operating their programs. The present research was undertaken to provide psychological tests, similar to those that have been so highly useful in other areas of education, to some segments of post high school trade and technical education.

More specifically, this research dealt with the development of psychometric instruments for measuring achievement in selected trade and technical education programs at the post high school level. The trade areas selected for study included: electrical installation and maintenance; radio and television servicing; air conditioning, heating and refrigeration; automotive mechanics; and machinists. The technical areas selected for study were electronics and data processing. These tests provide objective, reliable, and valid indices of the level of proficiency achieved by students and will provide teachers, administrators, and researchers with a tool for more effective management of their educational programs.

The present technical report covers the entire period of research and presents the rationale, procedures, and psychometric results for each of the areas mentioned above. Since the utility of the instruments developed during the course of this research program depends upon adequate test security, the instruments themselves are not included with this report. These instruments, which have been published separately, will be made available on an operational basis to interested educational institutions. However, the present report presents all of the technical information necessary for an institution to determine the appropriateness of the instruments for their curricula. This information includes detailed test specifications, descriptions of the samples, reliability of subtests, intercorrelations of subtests, correlations with other standardized measures of achievement, norms, and other psychometric data. The tests produced under this grant are listed below.

Achievement Test for Machinist
Auditory Achievement Test for Machinist
Achievement Test for Radio and Television Servicing
Visual Diagnostic Test for Television Servicing
Achievement Test for Air Conditioning, Heating and Refrigeration
Achievement Test for Automotive Mechanics
Auditory Achievement Test for Automotive Mechanics
Achievement Test for Electrical Installation and Maintenance
Achievement Test for Data Processing Technology - Business
Achievement Test for Data Processing Technology - Scientific
Achievement Test for Electronics Technology

This report is organized in several chapters. Chapter II deals with the overall program rationale and provides information on the decisions which were reached in the early part of the program regarding the selection of curriculum areas for study, selection of the environment in which the research would be conducted, and other information pertaining to the overall research program.

Chapter III deals with the procedures used in conducting this research and again is applicable to all curricula. Details are given regarding advisory committees, consultants, staff composition, item-writing committees, etc. Further detail is provided on how the various curricula were analyzed, weighted according to importance, and how items were generated, tested, and selected for inclusion in the final instruments.

Each of the chapters IV through X deals with the specific curriculum with which this research was concerned. For each curriculum, detailed information is presented on the test specifications, sample, and psychometric characteristics of both the experimental and final forms of the test. It is in these chapters that a potential user of the instruments will find detailed information which should be useful in making a decision regarding the appropriateness of the instrument for his particular purposes.

CHAPTER II

RATIONALE

A. SELECTION OF ENVIRONMENT

In 1956 the North Carolina General Assembly enacted legislation providing for a statewide system of "industrial education centers," the purpose of which was to provide both high school and post high school students training in vocational and technical education. By the fall of 1963 twenty such institutions had been established across the state and were serving the full-time equivalent of 8,588 students.[1]

In 1963 the North Carolina General Assembly enacted legislation which created a system of "community colleges, technical institutes, and industrial education centers" which provided for the creation of new institutions of each type and also provided that previously established industrial education centers could evolve into technical institutes or community colleges as the need arose.[2] By the fall of 1966 the system consisted of 47 separate institutions, thirteen of which were comprehensive community colleges offering college transfer, vocational, technical, and adult education programs. The remaining 34 institutions were technical institutes offering the same programs as the community colleges except that they did not offer the college transfer program. These institutions, in the fall of 1966, enrolled a full-time equivalency of 28,250 students, the majority of which were enrolled in vocational and technical programs.[3] By the fall of 1968 total enrollment had increased to a full-time equivalency of 45,902, of which 66 per cent was in occupational education. The institutions then numbered fifty.[4]

Because of the rapid growth noted above and with emphasis upon the development of quality in occupational programs, the state of North Carolina is an acknowledged leader in the field of occupational education in the southeastern United States and has gained a national reputation because of its efforts. For these reasons it was decided to rely heavily upon the North Carolina system in the development of achievement measures. This reliance included both students to take the tests and instructors to serve as subject-matter specialists in the development of test outlines and the construction of a pool of test items from which tests could be made.

An additional reason for reliance upon the North Carolina system was the presence of a well-developed and well-organized curriculum laboratory which has played a great role in the development of occupational curricula for implementation in the system. To this time the curriculum laboratory has developed curricula for approximately 49 technical and 43 trade programs.[1]

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[1] Enrollment data obtained from Julian Wingfield, Supervisor of Statistical Service, N.C. Dept. of Comm. Colleges, Raleigh, N.C.

[2] North Carolina, General Statutes of North Carolina, Chapter 115A

[3] Wingfield, op. cit.

[4] Ibid.

In the development of occupational curricula for the North Carolina system, the curriculum laboratory relies upon (1) a well-trained staff of curriculum specialists, (2) industrial representatives, and (3) administrators and instructors from institutions within the system.

The procedure followed in the development of a new curriculum is as follows. Once the need for a particular program has been established (through local and/or state surveys), the curriculum laboratory appoints an advisory committee consisting of representatives of industries which are potential employers, administrators from institutions which are likely to offer the new curriculum, and instructors or other personnel who may have special knowledge of the problem. Representatives from industry include both management and labor and are chosen for their knowledge in the field. Oftentimes, representatives from the Employment Security Commission and the North Carolina Department of Labor also serve on the advisory committees.

The advisory committee, working under the guidance of a curriculum specialist, develops a basic curriculum for the program which includes general course descriptions and time allocation for various courses. Next, the curriculum laboratory examines the curriculum to make sure that the civic and liberal objectives as well as the technical objectives are met. After revisions have been made, subject-matter specialists are called upon to develop course outlines and related instructional materials. Finally, the curriculum is published for use in the system where the need for such a curriculum can be demonstrated.

A block of courses which are considered to be either institutional or student electives is built into each curriculum. These electives, usually 10 to 20 per cent of the curriculum, may be used by a particular institution to develop courses to meet the needs of industries within their local service areas.

B. CURRICULUM AREAS

The selection of curricula for which achievement measures were developed was based mainly upon three criteria. The first criterion was the extent to which the curriculum laboratory of the North Carolina Department of Community Colleges and Technical Institutes had developed curriculum objectives, curriculum outlines, course objectives, course outlines, and related materials for a particular curriculum. The second criterion was the extent to which these developed curricula had been implemented throughout the system. The third criterion was gross system enrollment in a given curriculum. Using these criteria and considering the amount of work which could be accomplished with a given number of professional personnel and a fixed budget, seven curriculum areas, including two technologies and five trades, were selected for the development of achievement measures. The two technologies selected were (1) data processing and (2) electronics; the five trades were (1) air conditioning, heating, and refrigeration, (2) automotive mechanics, (3) electrical installation and maintenance, (4) machinist, and (5) radio and television servicing.

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[1] Technical and Trade Curriculums Manual, Curriculum Laboratory, N. C. Dept. of Community Colleges, Raleigh, N. C.

C. TYPE OF SAMPLE

Although, as noted above, the expertise of the North Carolina system was heavily relied upon, it was recognized by the staff that other states should be included in both the development of test instruments and the sampling of students. It was further recognized that two distinct approaches to occupational training prevail in the various states. Some states place great emphasis upon occupational training at the high school level through comprehensive high schools or vocational-technical high schools. Other states (particularly in the South) have not been successful in implementing such programs at the high school level and have turned to post high school institutions to accomplish occupational training. Finally, a subdifference in the post high school category exists in that some states have post high school technical institutes which offer only occupational training, whereas some states have comprehensive community colleges which also offer college transfer, general and basic adult education. Some states even combine both approaches.

It was decided by the project staff that each of the aforementioned approaches should be represented in the testing sample, but because of the heavy reliance upon post high school personnel, the prevalance of the post high school approach to occupational training in the South, and a limited budget, it was decided that the post high school approach would receive more emphasis. On this basis and for the initial testing effort conducted in the spring of 1967, all institutions offering curricula in which achievement measures were developed in both the North Carolina system of technical institutes and community colleges and the South Carolina system of technical education centers were asked to participate. Also, all technical colleges and vocational-technical high schools in Connecticut were asked to participate. Additionally, an institution in California, one in Colorado, one in Wisconsin, several in Georgia, one in Delaware, and institutions in three counties in New Jersey were asked to participate in the initial effort. These additional institutions represented both high school and post high school approaches to occupational training.

The institutions in California, Colorado, and Wisconsin declined to participate for various reasons. The Connecticut technical colleges agreed to participate, but the vocational-technical high schools declined on the grounds that they were already participating in a similar testing effort being conducted by another university. On the basis of these contacts, the first year's testing included six states with the number of students and institutions indicated below:

State	Institutions	Students
Connecticut	4	187
Delaware	1	43
Georgia	1	77
New Jersey	3	121
North Carolina	31	778
South Carolina	9	378
Total		

For the second year's testing, all participants in the first year's effort were asked to participate. In addition, other institutions in Georgia, institutions in the Virginia community college system, and certain vocational-technical high schools in Pennsylvania were asked to participate. On this basis, the second year's testing sample was as follows:

State	Institutions	Students
Connecticut	4	170
Delaware	1	55
Georgia	10	341
New Jersey	2	80
North Carolina	32	696
Pennsylvania	2	138
South Carolina	9	473
Virginia	1	39

CHAPTER III

PROCEDURES

A. ADVISORY COMMITTEE

To insure that the overall program design and plans for its implementation were sound, and to facilitate communication among both educators and researchers concerned with the goals of the investigation, an advisory committee was formed. Members of this committee were selected specifically to represent both academic research interests and the interests of those more closely associated with the type of training that was the subject of the project investigations. The committee met periodically as a group during early stages of the research and individual members were consulted throughout the research on matters related to their field of specilization. Members of the committee were:

Durwin M. Hanson, Professor and Head, Department of Industrial Education, North Carolina State University

Joseph T. Nerden, Professor, Department of Industrial Education, North Carolina State University

Monroe C. Neff, Assistant Director, North Carolina Department of Community Colleges, Head, Division of Vocational and Technical Education

Ivan E. Valentine, Assistant Director, North Carolina Department of Community Colleges, Head, Division of Vocational and Technical Education

Anthony J. Bevacqua, Coordinator of Curriculum Laboratory, North Carolina Department of Community Colleges

William H. Denton, Guidance Specialist, North Carolina Department of Community Colleges

Edward T. Brown, Supervisor of Research, North Carolina Department of Community Colleges

B. CONSULTANTS

In order to provide for a continuing assessment of the program by experts who were associated with neither the program nor the institution in which the research would be conducted, a panel of consultants was established. The panel consisted of authorities in the fields of psychology, education, and test development. Members of the panel provided individual consultation throughout the course of the project. The following individuals served as consultants on the project:

Dr. Rupert N. Evans, Dean, College of Education
University of Illinois

Dr. Robert F. Lockman, American Psychological Association,
Washington, D. C.

Dr. Norman E. Stander, Research Psychologist,
American Public Health Service, New York

Dr. Jacob Stern, Associate Professor of Education
Michigan State University[1]

Dr. Bert Westbrook, Associate Professor of Psychology,
North Carolina State University

C. PROJECT STAFF

Project staff members were needed who had backgrounds in both a subject-matter area as well as psychological measurement of education. The various staff members were recruited from North Carolina State University and other educational institutions. All members of the final staff had a background in either psychology or education, and at least one member had a background in each of the seven curricula.

All staff members were provided an orientation to the various participating institutions and with the curriculum laboratory. These orientation meetings aided in developing a close working relationship between the institutions and provided insight into the curriculum development. Each staff member was thus made more familiar with the areas in which the project would be working and was better able to coordinate the various activities of the item-writing committees, test administration, etc.

D. ITEM-WRITING COMMITTEES

Item-writing committees were formed for each subject-matter area for which an achievement test was to be constructed. Each committee consisted of five or six subject-matter specialists and at least one member of the project staff at North Carolina State University who was familiar both with the subject matter and with the technical procedures of test development. These subject-matter specialists were instructors in several of the institutions in which testing was to be conducted, and were primarily from institutions in North Carolina. However, in some instances, instructors were included from institutions in other participating states to insure a broad perspective.

It was important to insure that the most recent concepts within each field were covered by the tests. Therefore, only instructors who were currently engaged in teaching a given subject were used as subject-matter specialists. The fact that these instructors also attended workshops and institutes in their subject area aided in the development of comprehensive and current test instruments.

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[1] Now at the University of Illinois

E. ANALYSIS OF CONTENT UNITS

Each of the instructors who was serving on an item-writing committee was visited, and the objectives and operating procedures of the research project were outlined. Using a curriculum developed by the North Carolina Curriculum Laboratory each instructor was asked to do a complete analysis of that portion of the curriculum that he considered his trade or technical specialty. When the analyses were completed, meetings were held with these instructors in each of the seven technical or trade curricula included in the project. One of the major purposes of these meetings was to arrive at a consensus concerning the curriculum analysis.

When a consensus was reached, an outline was designed to serve as a guide in the development of the achievement tests. The final outline in each curriculum was subdivided into as many different areas as the committee members felt necessary to represent what they considered to be independent areas of instruction. Each independent area was then further subdivided to detail the various elements of the curriculum contained therein. The breakdown was used to insure that items for each item-pool would be truly representative of all aspects of that curriculum.

F. WEIGHTING OF CONTENT UNITS

In developing achievement tests that were truly representative of the cognitive learning experience, it was recognized that the subject matter was covered in varying degrees. That is, a certain amount of time is allocated to cover each aspect of the curriculum and an assessment of the resulting learning would have to reflect this emphasis.

The members of each committee were asked to arrive at a mutually acceptable outline of the percentage of time they felt was devoted to each subdivision within the curriculum. This percentage allocation reflected the varying degrees of emphasis that were placed on teaching the different parts of the subject-matter area. Such an outline was used to develop a comprehensive pool of test items that was not only representative of the material covered, but also of the amount of time spent teaching each aspect of the material.

G. LEVELS OF ITEM COMPLEXITY

Aside from insuring that all phases of the curriculum would be examined, the need for a way of conceptualizing the objectives of the various programs in behavioral terms became increasingly apparent. At the most general level, such a conceptualization provided the educators with a means of focusing their attention on the psychological processes used by the students to learn the materal in each curriculum.

The Taxonomy of Educational Objectives, _The Classification of Educational Goals, Handbook I: Cognitive Domain_ (Bloom, et al.) was examined since it represents the most elaborate attempt to use this basic approach. The project staff spent considerable time attempting to apply this system of classification to the curricula under study. It was found that considerable confusion existed among the industrial education teachers who were not familiar enough with education theory to use this system. It was therefore concluded that such a broad conceptulization of behavior was not a useful tool to provide subject-matter specialists.

A system that was more easily understood and insured a coverage of the levels of cognitive functioning appropriate for the students to be tested, was therefore developed. It evolved from a modification of Bloom's Taxonomy and consisted of four levels of classification. These four levels are: Knowledge, Understanding, Application of Knowledge, and Application of Understanding. Operational definitions of these four levels were developed for use and are presented below.

Knowledge Items of a test which measure knowledge require the repetition of responses that have been or should have been practiced in learning experiences prior to the time of taking the test. After learning, memory is the major requisite to correct performance.

Understanding Items of a test which measure understanding require responses in addition to those previously practiced and learned. The additional responses are likely to be interpretations, translations, summarizations, analyses, detection of similarities, detection of differences, etc. Items at this level do not set tasks which require solutions other than explorations in meaning.

Application of Knowledge Items of a test which measure application of knowledge require the use of previously learned responses in the solution of problems set by the items. At this level the problems are not new having been experienced by the testee before to the extent that responses that are necessary to find solutions are more or less routine.

Application of Understanding Solutions to problems in application of understanding require responses of the understanding level. At least one element of the problem is new to the testee. The newness might appear in either the conditions of the problem or in the solution required; that is, a new, novel solution might be required.

The various committee members met collectively several times to insure that all concerned with writing test items were in complete understanding of this classification system. Thus, when items were being written the instructors were aware that for each category on the curriculum outline the possibility existed that learning could be assessed at four conceptual levels.

H. ITEM GENERATION AND DEVELOPMENT

When they were well acquainted with the behavioral taxonomy that was to be used, the various curriculum item-writing committees met to outline the procedures for building a test-item pool. Since each instructor had one or more areas which was considered his specialty, it was decided that the best approach was to have each man write actual test items which they felt would adequately measure the student's acquisition of all relevant material in that curriculum area.

As the items were developed they were sent to the project staff. The items were then edited and evaluated in terms of grammatical correctness, format consistency, and adherence to accepted principles of test construction. The instructors wrote items in proportion to the degree of emphasis placed on the various subdivisions as agreed upon by the committees.

The item pool for each curriculum area was reproduced in booklet form to aid in evaluation. The various committees met periodically during the first year to review the items with regard to both their adequacy in attempting to measure student learning and to decide at which level on the taxonomic hierarchy each item should be placed. Many such meetings occurred as the various item pools began approaching six to seven hundred items each.

Each item was examined and discussed by the committee members. Only those that appeared to be satisfactory were actually chosen for inclusion in the experimental forms of the tests. In most instances, the final pool of acceptable items for each curriculum area totaled over six hundred.

I. DESIGN OF EXPERIMENTAL TESTS

With a pool of items constructed to represent each topic into which each curriculum had been divided, and at the same time to be representative of the four different levels of learning agreed upon by the staff, the compilation of the tests was begun. In order to examine a maximum number of items, it was decided that two experimental forms of each test would be developed.

The various item-writing committees compiled two separate tests from the pool of acceptable items. Aside from insuring that the tests reflected approximately the degree of emphasis depicted in the test specifications, special attention was devoted to the aspect of cognitive behavior measurement. That is, each content category of the specifications received approximately the same number of knowledge items, understanding items, etc. In this way each of the forms was made the parallel of the other.

Tests in the two technologies and in the five trade areas were developed, reproduced, assembled, and made ready for administration. In each of the seven curricula, with the exception of air conditioning, heating and refrigeration, two forms of each paper and pencil test were developed. After much consideration, it was the opinion of the staff that in the air conditioning, heating and refrigeration curriculum insufficient test material was available to develop two forms of the test. Therefore, all efforts in that curriculum were devoted to the development of one form of the test.

J. USE OF REFERENCE TESTS

Much thought and discussion was directed toward the best methodology for the evaluation of data gathered during the administration of the experimental achievement tests. It was decided that a complete item analysis for each item on each test should be done. This analysis included an evaluation of an item's relationship to the total score of the test, the total score on the subtest to which it belonged, and to all other subtests on the test. Item difficulty and effectiveness of distractors was also examined. A factor analysis was also done on each test in order to determine the actual number of factors being measured. In order to identify the factors isolated through factor analysis, it was decided that several short tests which measure relatively pure factors of intelligence should be administered along with the achievement tests. A thorough review of tests available led to the selection of a battery of research instruments titled "Reference Tests for Cognitive Factors." These tests were developed by Educational Testing Service in cooperation with the U. S. Office of Naval Research. Some of the most reputable people in testing research participated in the development of the reference kit which was designed for use in research studies. Each test in the kit was designed to be as pure as possible a measure of a single factor in the cognitive area. The kit contained tests which measured twenty-four different cognitive factors, and the tests were relatively short, ranging from three to twenty minutes in length. The project staff, in consultation with subject-matter specialists and other consultants, selected from five to eight of these tests for administration with each of our achievement tests. Tests were selected based upon their expert judgment that the cognitive factors measured by the respective tests contributed to achievement in a given trade or technology.

K. TEST ADMINISTRATION

With the completion of the selection of various reference tests, and with commitments from a number of institutions agreeing to participate, plans were finalized for the initial test administration. A schedule was set up which allowed for two days to be spent at each school. This was necessary since the total testing time, i.e., achievement tests and reference tests, was six hours. Three hours were scheduled for each day.

In the spring of 1967 administration was devoted almost exclusively to the electronics technology and data processing curricula as the termination of two-year programs in these areas occurred at this time. Samples from the various states ranged from a very small percentage of the testable population to practically the entire testable population.

The following procedure was used in administering the tests. Each curriculum area had two forms of the achievement test and several selected reference tests to be given. Half of the sample to be tested at each institution received form A and the other half form B. The achievement tests were designed such that approximately half the test was given on one day and the remainder on the next. Students also took the reference tests, which were given in a specified sequence, for each curriculum. This sequence was the rank order of judged importance of the reference tests for the particular curriculum. In that way, if for some reason the administration of all reference tests was impossible at a certain institution, at least those reference tests given would be the ones deemed most important.

In certain instances, it was found that some state's institutions were also having their trade curricula graduating at the end of the spring quarter. Therefore, provisions were made to examine these students at the same time that technology testing was being accomplished. Most of the spring trade testing was conducted in vocational-technical high schools in states which have separate post high school institutions for technical training.

Scheduling for the majority of the trade testing was during the summer months. The vast majority of trade training in North and South Carolina is done on a four quarter, one year, post high school basis. Students enter in the fall and are graduated in late August.

Test administration in the five trade areas was scheduled and conducted in much the same way as was testing in the two technologies. Two days were allotted us by each participating institution, with three hours each day being devoted to the testing program. Both the achievement tests and various reference tests for each curricula were administered; however, vocational students in many participating institutions were also scheduled to take various performance tests which were given at a different time.

A number of institutions were able to schedule an additional three hours of testing time for the administration of the performance tests. These tests, which are described in detail in the Appendix, attempted to measure directly the level of noncognitive performance attained. The behaviors measured were psychomotor or perceptual behaviors which were thought to contribute to a student's ability to perform the job for which he was being trained.

In order to insure that the administration of these tests was the same for everyone sampled, testing teams were organized and staff members were assigned to one or more of the performance tests. The test administrators were thus able to become very familiar with the test(s) assigned them, insuring that subjects received the tests under standardized conditions.

Some of the more complex performance tests, i.e., automotive electric and diagnostic scope tests, the radio-television diagnostic test, etc., were administered by individuals who were technically competent in the area. This proved valuable in that the testing devices were not always in good operative condition due to the many miles that they had to be transported. Most of the time, a technical adjustment would render the set operative again.

The performance tests were well received by both instructors and students. The latter were especially interested in the "doing" aspect of these tests in that they were able to "work with their hands."

L. EXPERIMENTAL TEST ANALYSIS

The primary objective of this research was to develop tests which were representative samplings of essential materials of the course of instruction. The relationship between test performance and an external criterion of performance was not therefore a major consideration. As is true of most achievement tests, the appropriate concept for validity in this project was content validity and this was insured by the use of experts in the field of instruction as described earlier.

All experimental pencil and paper achievement test scoring was performed on an IBM-1230 test scoring machine, but all the reference tests and performance tests required hand scoring. Since each student generated from five to ten tests that required hand scoring, it is conservatively estimated that over ten thousand tests were hand scored.

Analysis of the data generated by the testing program was done by computer. Computer analysis of the experimental tests included means and standard deviations for all subtests, all performance tests, and all reference tests. Split half reliabilities, item difficulty, biserial correlations for each item, response count for each distractor both above and below the mean were provided. Output also included subtest intercorrelations for all subtests, performance, and reference tests. As this output was received, correlation matrices were computed and factor analyzed. Test revisions were based on all this information.

With the completion of the computer analysis, results were made available to each of the participating institutions. The information presented included:

1. A raw score and a percentile score for each student by subtest.
2. An institution raw score mean and percentile mean for each subtest.
3. Raw score means and standard deviations for the entire sample.

4. Raw score and percentile means, by subtest, for each participating state.

5. A profile chart which depicted the institution's percentile standing by subject.

6. An outline covering the test or tests taken by the students in a particular institution.

All of the information was provided for both Form A or B. Also included were the results of the performance tests, with each subject's results based upon the entire sample that took a particular test. Reliabilities of all of the achievement subtests, reference tests, and performance tests were also made available.

M. TEST REVISION

Based upon the analyses discussed above, selection of items for inclusion in the final form of each test was begun. Several members of the original item-writing committees were invited to participate in the revision of the test for each curriculum.

In general, items were selected that had high biserial coefficients and that had moderate difficulty indeces. An item difficulty of from .30 to .70 means that from 30 to 70 per cent of those students answering the item got it correct. The most preferable situation was to have high biserial correlations with difficulty indeces in the moderate rather than extreme range.

Most of the committees discovered that there were enough items to meet these criteria so that additional new items were not required. In some cases a distractor had to be rewritten, or the stem of a question reworded, but the majority of acceptable items required no revision.

The committee working on the machinist test decided to incorporate the Safety subtest into the other subtests, selecting those items that were acceptable and applying them to the other content subtests. This procedure was also followed by the automotive committee.

The committee revising the air conditioning, heating and refrigeration test decided to include those acceptable items from the Fundamentals subtest in the other subtests where applicable. The radio-television committee decided to reduce the number of subtests from nine to seven, incorporating several concept areas into broader classifications.

The area that underwent the most extensive revision was data processing. Administration of the data processing achievement tests revealed several preliminary weaknesses of the instruments. First, the test used FORTRAN as the major programming language. Administration of the test in the various states revealed that some institutions use

COBOL as the primary language. Another weakness noted was that the emphasis upon accounting was insufficient for the business majors while the emphasis upon mathematics was too heavy for them but appropriate for the scientific majors. To remedy these weaknesses, a committee of data processing instructors from the various states sampled was formed. This committee had representatives from Connecticut, Georgia, North Carolina, and South Carolina technical education programs, and one member who was a computer programmer at the North Carolina State University Computing Center. It was the recommendation of this committee that separate subtests for business and scientific options be developed for mathematics and accounting and that subtests in both the FORTRAN and COBOL computer languages be developed to give each participating institution a language option. These suggestions were accepted, and a major revision based on these recommendations was undertaken.

All of the revised achievement tests were designed for a four-hour administration. Reference tests were not administered as part of the testing in the second year.

N. STATISTICAL ANALYSES

Results of a number of statistical analyses are reported in subsequent chapters for each test developed under this program. The following is a brief explanation of the statistical results reported and is provided so that the reader who is unfamiliar with them can interpret the results. The following references are also provided and will permit the reader to inquire in greater detail into the several concepts discussed.

Ghiselli, Edwin E. Theory of Psychological Measurement, McGraw-Hill, New York: 1964

Guilford, J. P. Psychometric Methods, McGraw-Hill, New York: 1954

Harman, Harry H. Modern Factor Analysis, University of Chicago Press, Chicago: 1967

Reliability The reliability of a test is an index of the consistency with which the test measures whatever it measures. In other words, will the test give the same results if used more than once? Test reliability is usually expressed as a reliability (correlation) coefficient which can range from 0.0 to 1.0. Zero indicates that the test is totally unreliable and gives entirely different results on repeated use. A coefficient of 1.0 indicates that the test is perfectly reliable and gives exactly the same results on repeated use.

Among the most common procedures for estimating the reliability of a test are "test-retest," the "alternate forms," and the "internal consistency" method. All three methods rely on deriving two sets of scores from the same test administered to the same subjects for the purpose of obtaining a reliability coefficient. The "test-retest" method arrives at two scores by testing the subjects on two different occasions. The score on the first administration of the test is correlated with the score on the second administration. Two parallel forms of the same test are administered to the subjects when the "alternate forms" method is used. Scores on these tests are then correlated. The "internal consistency" method relies on one administration of one form of the test and is thus economical in terms of administering time. The Kuder-Richardson method of internal consistency was used in this project since the assumptions underlying this method could be met easily. This method, which is really a series of formulas which vary in terms of the assumptions that can be made about the data, is based on the internal consistency of the test items. This approach allows the reliability estimate to be based on item statistics and at the same time hold computation to a minimum.

Correlation Analysis The correlation between two variables (e.g., test scores or item scores) is a measure of the correlationship between them. The correlation is expressed as a coefficient ranging from -1.0 to +1.0. A coefficient of -1.0 signifies a perfect negative correlation and exists when two variables are inversly proportional, i.e., when the value of one variable increases, the value of the other decreases proportionally. A coefficient of +1.0 indicates a perfect positive correlation and exists when two variables are directly proportional, i.e., when one variable increases, the other increases proportionally. Zero correlation exists when there is no relation between the two variables.

Correlation coefficients are often grouped together in a matrix which presents all possible intercorrelations between the several variables. Usually only one-half of the matrix is presented since the correlation between variable X and variable Y is equal to that between variable Y and variable X. Elements on the main diagonal are sometimes omitted as the correlation of a variable with itself is +1.0.

Factor Analysis The correlation matrix is the first step in factor analysis. Once a correlation matrix has been computed, it is sometimes desirable to investigate the underlying dimensions which the variables in the matrix have in common. Often the variables may overlap with two or more variables measuring the same attribute while others may be measuring attributes which are entirely separate. The purpose of factor analysis is to break down the correlation matrix into the separate dimensions or factors which represent the attributes measured by the original variables.

The factor matrix is composed of rows equal to the number of variables and columns equal to the number of extracted factors. The coefficients or factor loadings range from -1.0 to +1.0 and represent the correlation between the variable and the particular factor. The variables can be identified with the factors by inspecting the factor loadings. All variables with large loadings on a factor can be identified as measuring the attribute represented by the factor in question. The communality, (h^2), is an indication of the proportion of variance which a given variable has in common with other tests in the battery.

Skewness and Kurtosis The normal frequency distribution of scores is one which is symetrical with most scores falling in the middle of the scale around the mean. Fewer and fewer scores are found as the distance from the central point is increased with very few extremely low and high scores. A skewed distribution is one in which the highest frequency of scores is not in the center of the distribution but lies to the right or left. This type of distribution could result from an overly-easy or difficult test where most individuals received either high or low scores. The degree of skewness is expressed as coefficient of skewness. A coefficient of zero represents a symetrical distribution. Positive coefficients indicate that the highest frequency of scores fall in the lower range to the left of the central region of the scale. Negative coefficients indicate that the largest frequency of scores fall in the upper region of the scale.

Kurtosis refers to the degree of "flatness" of the frequency distribution. Flatness results when the scores are spread out evenly over the entire range. When a distribution is "flatter" than normal it is termed platykurtic. A leptokurtic frequency distribution, on the other hand, is one in which the scores tend to pile up in one region of the scale resulting in a more "peaked" curve than normal. The coefficient of kurtosis ranges from high positive values, indication a leptokurtic distribution, to high negative values representing a platykurtic distribution. A normal distribution has a coefficient of kurtosis equal to zero.

Norms Test scores have more meaning if they are referenced to the distribution of scores earned by a number of individuals. This referencing is accomplished by sampling the population of individuals for which the test was prepared. Test scores from this sample are analyzed and the mean, or measure of central tendency, and variance or spread of the scores, are computed. An individual's test score can then be compared to the results of this information. The adequacy of the norms is dependent on the number of cases involved and the representativeness of the sample to the total population selected.

Test scores that are referenced to a distribution of scores are usually reported in percentile rank or standard scores. The percentile rank of a score is the percentage of persons in the reference group who earn lower scores. Therefore, if a person falls at the 70th percentile, he has scored better than 70 per cent of the people taking the test.

Standard scores are based on mathematical characteristics of the distribution--the mean and standard deviation. The mean of the distribution is a measure of the central tendency and is equal to the sum of the individual scores divided by the number of scores. The standard deviation of a distribution is a measure of the spread of scores about the mean. A distribution, therefore, can be described by its mean and standard deviation. Raw scores can be transformed to a new distribution with a known mean and standard deviation. One such transformed distribution has a mean of 500 and a standard deviation of 100. It is this distribution that was used for tests reported in this report.

CHAPTER IV

DATA PROCESSING

A. EXPERIMENTAL TESTS

Tables IV-1 through IV-5 present test specifications, descriptions of the sample and detailed psychometric characteristics for the experimental Data Processing tests. Table IV-1, Test Specifications, presents the breakdown of course content which the item-writing committee developed. This table indicates the number of items considered necessary to sample each content area and also reflects the level of cognition necessary to master the particular content, i.e., knowledge, understanding, application of knowledge, or application of understanding. It should be noted that the number of items in both the experimental and final tests do not necessarily correspond to those in the table. The same relative emphasis was maintained in both forms of the test however. It should also be noted that subtests do not always correspond to major headings of the outline since other considerations were taken into account in grouping items into subtests.

Samples from the various states, reflected in Table IV-2, range from a very small percentage of the testable population to practically the entire testable population. In the states of Connecticut, North Carolina, and South Carolina practically all students scheduled to graduate at the end of the spring quarter or semester were tested. In North Carolina two of the four institutions offering Data Processing graduated their students at the end of the winter quarter. Since the achievement tests were not ready for administration at that time, over half of the testable sample was lost in that state.

From Table IV-3 it can be seen that reliabilities of experimental subtests range from .54 to .79. Tables IV-4 and IV-5 present the intercorrelations and factor analysis results for form A and B respectively. It can be seen that factor 1, which accounts for 27 per cent of the common variance, explains most of the correlation among the achievement subtests. Subtest I, Systems Concepts, and Subtest II, Applications, have high loadings on factor 1 while Subtest III, Mathematics and Statistics, and the Ship Destination and Symbol Production reference test, have moderate loadings on this factor. Subtest III and IV have their highest loadings on factor 4 and none of the reference tests have high loadings on this factor. The distinction between factors 1 and 4 appears to be that factor 1 is more related to the logic involved in data processing while factor 4 is more quantitative in nature, although this is not supported as strongly by reference test loadings as would be expected.

The factor analysis of form B shows that factor 1 does not measure achievement in Data Processing. Factor 2, which accounts for approximately 22 per cent of the variance, appears to explain most of the correlation among the achievement subtests. This factor appears to be the same as factor 1 for form A. None of the reference tests load on factor 2. Factor 4, which accounts for 16 per cent of the variance, again appears to be a quantitative factor with a high loading on Subtest IV, Accounting, and high loadings on the reference test Subtraction-Multiplication and Number Comparison. The two analyses agree fairly closely, the major difference being that Subtest III has its highest loading on the numerical factor in form A whereas it has its highest loading on the logic factor in form B.

B. FINAL TEST

The description of the sample for the Data Processing-Scientific and Business tests are presented in Tables IV-6 and IV-7. Psychometric characteristics of these tests are presented in Tables IV-8 through IV-11. It can be seen from Table IV-8 that the Data Processing-Scientific subtests have reliabilities ranging from .62 to .95, with a total test reliability of .97. It can also be seen from this table that skewness is negligible for all the subtests, although Subtest II and the total test are somewhat platykurtic. From the intercorrelations in Table IV-9 it can be seen that the tests share about the same degree of common variance and only one common factor appears to be measured by these subtests. (Factor analyses were not computed for final tests since no reference tests were administered.)

It can be seen from Table IV-10 that reliabilities for the Data Processing-Business range from .66 to .88 for subtests with a total test reliability of .92. It can also be seen that Subtest II, Programming Language, is negatively skewed and considerably leptokurtic, as is the total test. A comparison of Table IV-11 with Table IV-9 shows that the intercorrelations among the subtests for Data Processing-Business are more heterogeneous than for Data Processing-Scientific. For example, the relationship between achievement on Subtest I and III for Business students was not nearly as strong as it was for Scientific students.

Norms for converting raw scores to percentiles, and standard scores with a mean of 500 and a standard deviation of 100, are presented in Table IV-12 for subtests and Table IV-13 for total test scores for Data Processing-Business, and in Tables IV-14 and IV-15 for Data Processing-Scientific.

Table IV-1

DATA PROCESSING

Test Specifications

CURRICULUM CONTENT AREA	K	U	A_k	A_u
I. DATA PROCESSING SYSTEMS CONCEPTS				
A. Computer language and program aids				
1. FORTRAN	6	2	3	
2. COBOL	3			
3. Symbolic	4	4		
4. Programming aids	3	1	1	
5. Machine language	1	4		
B. Unit record	12	9		
C. Input/output	8	5		
1. Tape (paper and mag)	6	1		
2. Card	11			
3. Printer	10	4	1	
4. Magnetic ink character recognition	3			
5. Optic devices	1	1		
D. Memory	3	5		
1. Core	1	1		
2. Disc	1	1		
3. Drum		1		
E. Computer logic	1	3		
1. High/low, equal, compare	2	1		
2. Sense switch				
F. Arithmetic unit	2			
1. Tables				
2. Registers	1			
G. History and development	7			
II. MATHEMATICS				
A. Algebra				
1. Basic algebra		12	1	
2. Linear equations		6	3	
3. Matrix theory	3	3	4	
4. Quadratics	1		3	2
B. Numbering systems				
1. Conversion (current systems)	1		7	3
2. Operations			7	
C. Statistics				
1. Measurement of central tendency and dispersion	2	2		
2. Correlation	1	2		
3. Test of hypothesis (X^2, t-test, ANOV)		1	3	
D. Logical math				
1. Boolean expressions			1	2
2. Logic diagrams and circuits			2	3
3. Truth tables		1		1
E. Trigonometry		2	5	2
F. Geometry	2	1	1	2

	K	U	A_k	A_u
III. APPLICATIONS				
A. Accounting	1	1		
1. Payroll		1	1	
2. Sub-ledgers (AR&P, inventory	2	8		
B. Scientific Management	1			
1. Linear programming and critical path	1		8	2
2. Real-time	1		1	
3. Tele-processing				
4. Multi-processing				
C. Statistics	13	8	1	1
1. Data analysis		4	7	10
2. Probability		8	12	6
D. Systems and procedures		2		
1. Total system concept		1	1	
2. Feasibility study				
3. Decision tables	1	2		
IV. ACCOUNTING				
A. Cost accounting				
1. Cost systems-job, process and standard	3			
2. Elements of cost - material, labor, and overhead		6		
3. Inventories - FIFO, LIFO, and average	2			
4. Variance analysis		1	1	
B. Corporation accounting				
1. Financial statements - balance sheet, P & L, and capital	3	3		
2. Assets - ledger accounts	2			
3. Liabilities - ledger accounts		1		
4. Capital - ledger accounts	4	3		
5. Ratios - ledger accounts	1			
C. Proprietorship				
1. Accounting equation - A = L+P	2			
2. Accounting cycle				
a. Account	3	2		
b. Trial balance				
c. Journal and ledgers	1	1		
d. Periodic summary	1	3		
D. Partnership				
1. Voucher system	1			
2. Payroll				
3. Taxes				
4. Capital structure - partnership vs corporation	2	1	2	

Table IV-2

DATA PROCESSING
First Year

Description of Sample

State	No. of Institutions	No. of Students
Connecticut	4	73
Georgia	1	16
North Carolina	17	44
South Carolina	6	46
	28	179

Table IV-3

DATA PROCESSING
Experimental Tests

Description and Reliabilities

	Subtest	Time Limit (min)	Form A	Form B	Form A	Form B
I	Data Processing Systems-Concepts	50	60	60	.73	.79
II	Data Processing Systems-Applications	90	60	60	.72	.79
III	Mathematics and Statistics	75	50	50	.76	.65
IV	Accounting	25	30	30	.65	.54
	Total	240	200	200		

Table IV-4

INTERCORRELATIONS AND FACTOR LOADINGS FOR DATA PROCESSING

Experimental Test - Form A

	Intercorrelations															
	Subtest				Reference Test							Factor Loadings				
	I	II	III	IV	ShD	SM	WRV	NC	Inf	WE	SP	1	2	3	4	h^2
I	--	39	46	27	36	18	23	-03	18	21	21	72	27	-16	25	68
II		--	32	19	18	30	04	15	04	21	25	78	-08	22	03	66
III			--	34	23	23	25	10	29	32	21	42	26	-01	60	60
IV				--	04	26	25	13	18	03	34	14	11	22	78	69
ShD					--	23	34	-04	45	22	12	41	64	-12	-09	60
SM						--	02	46	15	11	26	34	00	68	19	61
WRV							--	18	45	34	11	-03	80	09	18	68
NC								--	19	24	08	-09	13	87	02	78
Inf									--	24	12	-01	79	13	18	39
WE										--	25	33	47	36	-42	63
SP											--	44	04	28	25	34
											% Var	27.5	29.6	22.9	20.0	
											Cum %	27.5	57.1	80.0	100.0	

n = 81
Decimals omitted

Table IV-5

INTERCORRELATIONS AND FACTOR LOADINGS FOR

DATA PROCESSING

Experimental Test - Form B

	Intercorrelations															
	Subtest				Reference Tests							Factor Loadings				
	I	II	III	IV	ShD	SM	WRV	NC	Inf	WE	SP	1	2	3	4	h^2
I	--	47	29	18	28	04	18	05	36	12	10	-06	-73	41	00	70
II		--	35	02	11	19	07	12	-02	14	09	14	-82	-12	00	71
III			--	15	18	17	08	27	14	15	19	22	-64	-01	21	50
IV				--	10	26	13	09	14	-05	16	30	-13	26	66	61
ShD					--	16	08	-05	28	14	18	-02	-36	43	05	32
SM						--	00	53	30	26	06	28	-08	-01	81	74
WRV							--	06	49	22	16	19	03	77	-08	64
NC								--	28	41	26	67	-03	-08	56	77
Inf									--	26	11	21	-01	78	28	73
WE										--	33	30	-07	19	02	13
SP											--	55	-17	18	-01	36
											% Var.	42.0	21.7	19.8	16.5	
											Cum. %	42.0	63.7	83.5	100.0	

n = 82
Decimals omitted

Table IV-6

DATA PROCESSING - BUSINESS
Second Year

Description of Sample

State	No. of Institutions	No. of Students
Connecticut	2	12
Georgia	1	18
South Carolina	7	43
	7	73

Table IV-7

DATA PROCESSING -SCIENTIFIC
Second Year

Description of Sample

State	No. of Institutions	No. of Students
Connecticut	4	56
North Carolina	2	32
Pennsylvania	2	36
	8	124

Table IV-8

DATA PROCESSING-SCIENTIFIC

Psychometric Characteristics
Final Test

	Subtest	No. of Items	Time Limit	Reliability K-R (14)	Skewness	Kurtosis
I	Data Processing Systems Fundamentals	70	60 min	91	-21	-81
II	Programming Lang. Appl. FORTRAN	60	60 min	95	03	-1.35
III	Statistics	25	30 min	62	-07	-55
IV	Mathematics	40	60 min	88	51	-24
V	Accounting - General	40	30 min	81	21	-19
	Total test			95	00	-1.12

Table IV-9

DATA PROCESSING-SCIENTIFIC

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V
I	--	80	64	69	56
II		--	60	68	32
III			--	70	53
IV				--	59
V					

Decimals omitted

Table IV-10

DATA PROCESSING-BUSINESS

Psychometric Characteristics
Final Test

	Subtest	No. of Items	Time Limit	Reliability K-R (14)	Skewness	Kurtosis
I	Data Processing Systems Fundamentals	70	60 min	73	-22	09
II	Programming Lang. Appl. COBOL	60	60 min	88	-1.50	3.97
III	Statistics	25	30 min	66	34	-24
IV	Mathematics	25	30 min	67	24	-28
V	Accounting - General	40	30 min	75	-14	70
VI	Accounting - Cost	30	30 min	71	-12	-07
	Total test			92	-52	1.96

Table IV-11

DATA PROCESSING-BUSINESS

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V	VI	TOTAL*
I	--	55	35	41	37	33	79
II		--	34	24	62	21	84
III			--	32	29	06	51
IV				--	11	-05	42
V					--	37	74
VI						--	51
Total							--

*Part-whole correlations
Decimals omitted

Table IV-12

RAW SCORE CONVERSIONS

DATA PROCESSING - BUSINESS SUBTESTS

Raw Score	1		2		3		4		5		6	
	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
55	99	690										
54	99	682	99	667								
53	99	674	99	662								
52	99	667	99	656								
51	99	659	97	651								
50	97	651	97	646								
49	96	644	96	640								
48	95	636	96	635								
47	93	628	96	629								
46	90	620	95	624								
45	88	613	92	619								
44	85	605	89	613								
43	82	597	85	608								
42	79	589	79	602								
41	75	582	78	597								
40	71	574	75	591								
39	63	566	74	586								
38	63	558	71	581								
37	60	551	68	575								
36	55	543	64	570								
35	55	535	62	564					99	772		
34	53	528	58	559					99	758		
33	51	520	56	554					97	745		
32	49	512	55	548					97	731		
31	48	504	53	543					97	717		
30	47	497	52	537					97	703		
29	45	489	49	532					97	689		
28	44	481	49	527					97	676		
27	42	473	48	521					97	662		
26	42	466	48	516					96	648		
25	42	458	47	510					95	634		
24	41	450	45	505					88	620		
23	41	442	45	500					86	607		
22	40	435	45	494					78	593		
21	37	427	45	489					75	579		
20	34	419	45	483					71	565		
19	34	412	45	478					70	551	99	740
18	27	404	45	473					67	538	98	716
17	27	396	45	467					64	524	97	693
16	23	388	45	462			99	814	59	510	97	690
15	15	381	45	456	99	848	99	782	56	496	93	647
14	8	373	45	451	99	810	99	749	52	482	93	624
13	8	365	45	445	99	773	97	716	48	469	88	600
12	7	357	45	440	97	735	96	683	41	455	77	577
11	4	350	45	435	96	697	92	650	37	441	72	554
10	1	342	45	429	94	659	89	618	33	427	60	531
9			45	424	93	621	86	585	26	413	58	508
8			44	418	89	584	78	552	19	400	53	485
7			42	413	77	546	68	519	11	386	42	461
6			41	408	66	508	60	487	7	372	37	438
5			38	402	55	470	47	454	7	358	27	415
4			34	397	28	432	25	421	4	344	25	392
3			26	391	17	395	14	388	3	331	12	369
2			14	386	8	357	7	355			3	345
1			1	381	3	319	3	323			2	322

Table IV-13

RAW SCORE CONVERSION

DATA PROCESSING - BUSINESS TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
193	99	754	140	92	626	87	47	498	34	3	370
192	99	751	139	92	623	86	47	495	33	3	367
191	99	749	138	92	621	85	47	493	32	1	365
190	99	747	137	92	619	84	47	490			
189	99	744	136	90	616	83	45	488			
188	99	742	135	88	614	82	44	486			
187	99	739	134	86	611	81	44	483			
186	99	737	133	86	609	80	44	481			
185	99	735	132	86	606	79	44	478			
184	99	732	131	85	604	78	44	476			
183	99	730	130	85	602	77	44	474			
182	99	727	129	85	599	76	44	471			
181	99	725	128	82	597	75	44	469			
180	99	722	127	81	594	74	44	466			
179	99	720	126	79	592	73	44	464			
178	99	718	125	78	590	72	44	461			
177	99	715	124	77	587	71	44	459			
176	99	713	123	74	585	70	44	457			
175	99	710	122	73	582	69	44	454			
174	99	708	121	71	580	68	44	452			
173	99	706	120	70	577	67	44	449			
172	99	703	119	68	575	66	44	447			
171	99	701	118	68	573	65	44	445			
170	99	698	117	67	570	64	44	442			
169	99	696	116	67	568	63	44	440			
168	99	693	115	64	565	62	44	437			
167	99	691	114	64	563	61	44	435			
166	99	689	113	64	561	60	42	432			
165	99	686	112	62	558	59	42	430			
164	99	684	111	62	556	58	41	428			
163	99	681	110	60	553	57	41	425			
162	99	679	109	60	551	56	38	423			
161	99	677	108	60	548	55	37	420			
160	99	674	107	60	546	54	36	418			
159	99	672	106	59	544	53	34	415			
158	99	669	105	59	541	52	33	413			
157	99	667	104	59	539	51	33	411			
156	99	664	103	58	536	50	30	408			
155	99	662	102	56	534	49	29	406			
154	96	660	101	53	532	48	28	403			
153	96	657	100	53	529	47	27	401			
152	95	655	99	52	527	46	25	399			
151	95	652	98	51	524	45	25	396			
150	95	650	97	51	522	44	23	394			
149	95	648	96	51	519	43	19	391			
148	95	645	95	49	517	42	19	389			
147	95	643	94	49	515	41	18	386			
146	95	640	93	49	512	40	14	384			
145	95	638	92	48	510	39	10	382			
144	95	635	91	47	507	38	8	379			
143	95	633	90	47	565	37	7	377			
142	95	631	89	47	503	36	7	374			
141	93	628	88	47	500	35	7	372			

Table IV-14

RAW SCORE CONVERSIONS

DATA PROCESSING - SCIENTIFIC SUBTESTS

Raw Score	1		2		3		4		5	
	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
59	99	715								
58	99	706								
57	99	698								
56	99	690	99	687						
55	99	682	99	680						
54	99	674	98	673						
53	99	666	98	667						
52	98	658	98	660						
51	97	649	98	653						
50	95	641	96	646						
49	94	633	94	639						
48	92	625	91	623						
47	90	617	87	625						
46	87	609	86	618						
45	83	600	85	611						
44	78	592	85	604						
43	77	584	82	597						
42	73	576	79	590						
41	69	568	75	583						
40	69	560	72	576						
39	65	551	66	569						
38	65	543	63	562						
37	60	535	60	555						
36	57	527	59	549						
35	56	519	57	542						
34	53	511	57	535						
33	52	503	56	528						
32	47	494	54	521						
31	43	486	53	514						
30	40	478	53	507						
29	39	470	53	500						
28	38	462	50	493					99	718
27	36	454	49	486					98	702
26	32	445	48	479					98	688
25	32	437	46	472					96	574
24	27	429	44	465					93	549
23	23	421	44	458					89	644
22	19	413	41	451			99	744	89	629
21	18	405	40	444			99	724	89	615
20	18	396	38	437			98	704	81	600
19	18	388	36	431			96	684	75	585
18	18	380	30	424			95	664	74	570
17	14	372	27	417			93	644	72	556
16	12	364	24	410			88	624	67	541
15	19	356	21	403			85	604	63	526
14	10	347	17	396			80	584	63	511
13	8	339	15	389	99	706	75	564	56	497
12	8	331	15	382	97	672	72	544	51	482
11	6	323	15	375	92	639	66	524	49	467
10	3	315	11	368	89	605	60	504	46	452
9	2	307	8	361	80	571	55	483	35	438
8	2	299	6	354	70	537	42	463	30	423
7	1	290	5	347	55	503	32	443	19	408
6	1	282	4	340	45	469	24	423	14	393
5	1	274	3	333	34	436	20	403	7	379
4	1	266	2	326	25	402	14	383	7	364
3			2	319	14	368	11	363	55	349
2			2	313	8	334	9	343	5	334
1					1	300	4	323	4	320

Table IV-15

RAW SCORE CONVERSIONS

DATA PROCESSING - SCIENTIFIC TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
142	99	698	98	66	560	54	24	421
141	99	695	97	66	557	53	23	418
140	99	692	96	64	553	52	23	415
139	99	689	95	61	550	51	21	411
138	99	686	94	61	547	50	20	408
137	99	683	93	61	544	49	20	405
136	99	680	92	60	541	48	20	402
135	98	676	91	57	538	47	20	399
134	98	673	90	56	534	46	19	396
133	98	670	89	55	531	45	19	392
132	98	667	88	54	528	44	19	389
131	98	664	87	53	525	43	19	386
130	98	661	86	53	522	42	18	383
129	98	657	85	52	519	41	18	380
128	98	654	84	52	516	40	15	377
127	96	651	83	50	512	39	15	374
126	95	648	82	50	509	38	14	370
125	95	645	81	49	506	37	14	367
124	95	642	80	47	503	36	13	364
123	95	639	79	47	500	35	12	361
122	95	635	78	47	497	34	11	358
121	92	632	77	42	493	33	10	355
120	92	629	76	40	490	32	8	351
119	92	626	75	40	487	31	8	348
118	91	623	74	40	484	30	8	345
117	91	620	73	40	481	29	8	342
116	89	616	72	40	478	28	7	339
115	88	613	71	40	475	27	6	336
114	86	610	70	40	471	26	6	333
113	86	607	69	39	468	25	6	329
112	84	604	68	38	465	24	5	326
111	84	601	67	37	462	23	5	323
110	82	598	66	37	459	22	4	320
109	82	594	65	37	456	21	4	317
108	80	591	64	35	452	20	4	314
107	89	588	63	33	449	19	4	310
106	79	585	62	31	446	18	4	307
105	78	582	61	31	443	17	3	304
104	76	579	60	31	440	16	2	301
103	76	575	59	30	437	15	2	298
102	73	572	58	30	433	14	2	295
101	71	569	57	27	430			
100	69	566	56	25	427			
99	67	563	55	24	424			

CHAPTER V

ELECTRONICS

A. EXPERIMENTAL TESTS

Tables V-1 through V-5 present test specifications, descriptions of the sample, and psychometric characteristics of the experimental Electronics tests. These tests were administered to a total of 338 students during the first year and 327 during the second year in five different states. The majority of the students were completing a two-year post high school training program in community colleges or technical institutes in Connecticut, Georgia, North Carolina, and South Carolina. In addition to these institutions, two vocational-technical high schools in Pennsylvania also participated in this testing.

From Table V-3 it can be seen that reliabilities of the experimental subtests range from .56 to .83. Table V-4 presents the intercorrelations and factor analysis for form A of the experimental tests. High loadings for all achievement tests are found on factor 1, which accounts for 59 per cent of the common variance. As no reference tests have significant loadings on factor 1, it can be concluded that this factor is measuring achievement in Electronics Technology and is independent of the dimensions measured by the reference tests.

Table V-5 presents the intercorrelations and factor analysis for form B of the experimental tests. All subtests have high loadings on factor 1, which accounts for 65 per cent of the common variance. No reference tests load on this factor, indicating that the factor underlies achievement in Electronics Technology. Analyses for form A and form B agree fairly closely.

B. FINAL TEST

Tables V-6 through V-8 present the description of the sample, the psychometric characteristics, and the intercorrelations for the final tests. The reliabilities range from .76 to .86 for the subtests with a reliability of .96 for the total test. From the same table it can be seen that the distributions for the subtests are slightly skewed and slightly platykurtic. The intercorrelations in Table V-8 indicate that the subtests share about the same degree of common variance.

Norms for converting raw scores to percentiles and standard scores are presented in Table V-9 for the subtests and Table V-10 for total test scores.

Table V-1

ELECTRONICS

Test Specifications

CURRICULUM CONTENT AREA	K	U	A_k	A_u
I. Fundamentals of Electricity				
A. Direct current				
1. Electron physics	3	1		
2. Ohm's Law (power and efficiency)				
a. Series, parallel circuits	1	3	2	1
b. Series-parallel circuits		1	1	
3. Kirchoff's Law				
a. Series - parallel circuits			2	
b. Series - parallel circuits			2	2
4. Loop analysis		1	1	3
5. Node analysis				
6. Superposition theorem		1		
7. Norton's theorem	1			
8. Thevenin's theorem			1	
9. Electrostatics and capacitance	1	1	2	
10. Magnetism				
a. Permanent magnets		1	1	
b. Electromagnetics	1	1		
c. Meter movements	1		1	
11. Time constants		2	1	
B. Alternating current				
1. Rotating vectors			6	3
2. Voltage and current generation		1	2	2
3. Reactance				
a. Capacitance		3	3	
b. Inductive	1	5	4	
c. Phase angles		4	1	
4. Impedence				
a. Series	2		2	
(1) L-R		3	1	1
(2) C-R	1	2	2	
(3) L-C-R		1	4	
b. Parallel				
(1) L-R		1	1	
(2) C-R		4	2	
(3) L-C-R		2		1
5. Resonance		1	2	
a. Series	1	1	3	2
b. Parallel	1	4	5	
6. Transformers	4	5	7	1
II. FUNDAMENTALS OF ELECTRONICS				
A. Introduction to vacuum tubes				
1. Electron emission	4	3		
2. Diodes	1	4	6	1
3. Triodes	3	6	6	3
4. Multi-element	2	11	2	1

	K	U	A_k	A_u
B. Introduction to semi-conductors				
1. Solid-state physics	18	6	1	
2. Semi-conductor diodes	4	12	5	1
3. Junction transistors	12	21	3	
4. Field effect transistors	8	5	1	
III. APPLICATION OF ELECTRONICS				
A. Active networks				
1. Power supply		3	2	
a. Half-wave	1		1	
b. Full-wave	1			
(1) Bridge		2		
(2) Conventional	2	1	1	
c. Voltage-multiplying		3	4	
d. Filter networks		2	2	2
2. Amplifiers	4	9	1	
a. Voltage	5	16	10	1
b. Current	3	5	2	
c. Power		4	4	
3. Oscillators	1	1		
a. Sinusoidal	8	5		1
b. Non-sinusoidal	1		1	
4. Stabilization	2	2		
IV. SPECIAL CIRCUITRY				
A. Wave shaping				
1. Phase shifting		1		
a. Integrating circuits		2	1	
b. Differentiating circuits	1	3	1	3
2. Harmonic analysis	2	3	1	
3. Clipping and clamping	2	4	12	2
B. Non-sinusoidal oscillators				
1. Multi-vibrators	6	13	3	2
2. Relaxation	1	2	1	
3. Blocking	2	3	1	1
C. Feedback				
1. Positive	3	1		
2. Negative		6		2
D. Gating circuits			3	
E. Logic circuits	2	2	12	1
F. Switching circuits			5	3
V. INSTRUMENTATION				
A. Basic meters				
1. Movements	4	2		
2. Circuits	3	3	6	2
B. Oscilloscopes	1	9	2	
C. Transducers	3	7	2	3
D. Application and limitations of measuring devices	2	6	2	4

		K	U	A_k	A_u
VI.	SPECIAL DEVICES				
	A. Gas tubes	1			
	1. Diodes	2			
	2. Thyratrons		1		
	B. Cathode - ray tubes	1	1		
	C. Zener diode	2	1		
	D. Tunnel diode	2	3		
	E. Thermisters	1		1	
	F. Switching diodes				
	G. Silicon control rectifiers	1			
	H. Syncro and servo systems	4	3		
VII.	SYSTEMS ANALYSIS				
	A. Block diagrams	1	3	5	
	B. Functional diagrams				
	1. Signal flow	1	4		
	2. Feedback loops		1		
	3. Functional analysis	4	7	4	
	C. Troubleshooting principles	2	4	11	4

Table V-2

ELECTRONICS - First Year

Description of Sample

State	No. of Inst.	No. of Stu.
Connecticut	4	115
Georgia	1	6
New Jersey	1	7
North Carolina	17	143
South Carolina	6	67
	29	338

Table V-3
ELECTRONICS

Experimental Tests
Description and Reliabilities

	Subtest	Time Limit (Min)	No. of Items Form A	No. of Items Form B	Reliability Form A	Reliability Form B
I	Fund. of Electricity	60	50	50	.77	.81
II	Fund. of Electronics	50	50	50	.77	.75
III	Appl. of Electronics	50	50	50	.78	.83
IV	Special Circuitry	50	50	50	.77	.81
V	Instrumentation	30	30	30	.76	.71
VI	Special Devices and Systems Analysis	40	40	40	.66	.56
	Total	280	270	270		

Table V-4

INTERCORRELATIONS AND FACTOR LOADINGS FOR ELECTRONICS

Experimental Test - Form A

	Intercorrelations															
	Subtest						Reference Tests						Factor Loadings			
	I	II	III	IV	V	VI	ShD	SM	WRV	NC	Inf		1	2	3	h^2
I	--	58	42	49	62	47	20	-12	35	00	20		70	-12	22	55
II		--	68	63	63	58	15	-12	31	-10	21		82	-15	04	70
III			--	62	61	60	19	-20	23	-12	16		80	-12	-07	66
IV				--	60	60	26	-21	24	-04	09		82	-02	02	67
V					--	55	28	-24	32	00	08		83	-02	10	70
VI						--	22	-24	21	00	05		80	02	-04	64
ShD							--	06	35	08	14		28	-08	69	56
SM								--	-08	24	08		-34	12	64	54
WRV									--	-18	42		32	-52	45	58
NC										--	61		01	86	34	86
Inf											--		06	-89	19	83
												% Var.	59.1	23.5	17.4	
												Cum. %	59.1	82.6	100.0	

n = 132
Decimals omitted

Table V-5

INTERCORRELATIONS AND FACTOR LOADINGS FOR

ELECTRONICS
Experimental Test - Form B

	Intercorrelations														
	Subtest						Reference Tests					Factor Loadings			
	I	II	III	IV	V	VI	ShD	SM	WRV	NC	Inf	1	2	3	h^2
I	--	69	56	53	63	48	17	-02	35	05	30	76	06	19	62
II		--	71	56	70	57	18	-03	38	04	37	83	02	20	73
III			--	63	65	68	14	-10	35	11	34	87	01	11	77
IV				--	65	62	24	-02	42	02	40	74	-01	32	65
V					--	56	25	-05	44	07	42	79	03	32	73
VI						--	08	-12	24	-07	30	80	-18	03	67
ShD							--	06	24	09	20	07	22	58	39
SM								--	03	27	04	-14	71	19	56
WRV									--	04	53	29	00	75	65
NC										--	-10	12	84	-12	73
Inf											--	27	-15	76	67
% Var.												65.1	19.0	15.9	
Cum. %												65.1	84.1	100.0	

n = 129
Decimals omitted

Table V-6

ELECTRONICS
Second Year

Description of Sample

State	No. of Insitutions	No. of Students
Connecticut	4	102
Georgia	9	89
North Carolina	13	88
Pennsylvania	2	14
South Carolina	8	79
	36	372

Table V-7

ELECTRONICS

Psychometric Characteristics
Final Test

	Subtest	No. of Items	Time Limit	K-R (14)	Skewness	Kurtosis
I	Fundamentals of Electricity	40	45 min	85	44	-10
II	Fundamentals of Electronics	45	45 min	84	18	-46
III	Instrumentation	30	30 min	81	17	-56
IV	Application of Electronics	45	45 min	86	17	-37
V	Special Circuitry	45	45 min	81	39	-26
VI	Systems Analysis	30	30 min	76	-03	-41
	Total test			96	34	-13

Table V-8

ELECTRONICS

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V	VI	TOTAL*
I	--	65	63	50	62	47	78
II		--	73	68	69	55	85
III			--	59	65	55	83
IV				--	73	58	84
V					--	64	88
VI						--	74
Total							--

*Part-whole correlations
Decimals omitted

Table V-9

RAW SCORE CONVERSIONS

ELECTRONICS SUBTESTS

	1		2		3		4		5		6	
Raw Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
41							99	794				
40							99	782				
39							99	771				
38			99	772			99	760				
37			99	762			99	749				
36	99	826	99	752			98	738	99	807		
35	99	813	99	742			98	726	99	794		
34	99	799	98	731			97	715	99	781		
33	99	785	98	721			96	704	99	768		
32	99	771	97	711			95	693	98	755		
31	99	758	96	701			94	681	97	742		
30	98	744	95	690			92	670	97	729		
29	97	730	93	680			91	659	96	716		
28	96	716	92	670			90	648	95	703		
27	95	703	90	660	99	784	89	637	95	690		
26	95	689	89	649	99	770	87	625	94	677		
25	93	675	88	639	99	756	86	614	92	664		
24	91	661	86	629	99	742	81	603	91	651		
23	90	648	84	619	99	728	80	592	89	638	99	778
22	89	634	82	609	98	714	79	580	88	625	99	759
21	88	620	81	598	96	700	76	569	86	612	98	740
20	85	606	79	588	94	687	74	558	83	599	98	721
19	83	593	76	578	92	673	73	547	80	586	96	702
18	81	579	75	568	90	659	71	536	78	573	94	682
17	77	565	74	557	88	645	69	524	77	560	92	663
16	76	551	71	547	86	631	65	513	73	547	90	644
15	73	537	69	537	83	617	64	502	72	534	87	625
14	71	524	67	527	81	603	60	491	70	521	84	606
13	69	510	65	516	78	589	56	479	66	508	80	587
12	62	496	64	506	75	576	52	468	63	495	79	567
11	56	482	62	496	73	562	45	457	58	482	76	548
10	51	469	60	486	71	548	37	446	54	469	72	529
9	42	455	56	475	68	534	31	435	48	456	66	510
8	35	441	54	465	66	520	26	423	38	443	60	491
7	26	427	51	455	64	506	21	412	30	430	53	471
6	21	414	47	445	63	492	15	401	22	417	41	452
5	16	400	41	434	62	478	12	390	16	404	31	433
4	9	386	32	424	61	465	7	379	9	391	22	414
3	5	372	23	414	60	451	3	367	5	378	15	395
2	3	359	13	404	54	437	3	356	2	365	10	375
1	2	345	8	394	33	423	2	345	1	351	5	356

Table V-10

RAW SCORE CONVERSIONS

ELECTRONICS TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
191	99	801	138	92	673	85	70	546	32	17	418
190	99	798	137	91	671	84	70	543	31	15	416
189	99	796	136	91	668	83	70	541	30	12	414
188	99	793	135	91	666	82	69	539	29	10	411
187	99	791	134	91	664	81	69	536	28	9	409
186	99	789	133	90	661	80	68	534	27	8	406
185	99	786	132	90	659	79	68	531	26	7	404
184	99	784	131	90	656	78	68	529	25	6	401
183	99	781	130	90	654	77	67	527	24	5	399
182	99	779	129	89	652	76	67	524	23	4	397
181	99	777	128	89	649	75	67	522	22	3	394
180	99	774	127	88	647	74	67	519	21	3	392
179	99	772	126	88	644	73	67	517	20	3	389
178	99	769	125	88	642	72	66	515	19	2	387
177	99	767	124	87	640	71	66	512	18	2	385
176	99	765	123	87	637	70	65	510	17	1	382
175	99	762	122	86	635	69	65	507	16	1	380
174	99	760	121	86	632	78	65	505	15	1	377
173	99	757	120	85	630	67	64	502	14	1	375
172	99	755	119	85	628	66	64	500	13	1	373
171	99	753	118	84	625	65	63	498	12	1	370
170	99	750	117	84	623	64	63	495	11	1	368
169	99	748	116	84	620	63	63	493	10	1	365
168	99	745	115	83	618	62	63	490	9	1	363
167	98	743	114	83	616	61	63	488	8	1	361
166	98	741	113	83	613	60	63	486	7	1	358
165	98	738	112	82	611	59	63	483	6	1	356
164	98	736	111	81	608	58	63	481			
163	98	733	110	80	606	57	63	478			
162	98	731	109	80	603	56	62	476			
161	97	729	108	80	601	55	62	474			
160	97	726	107	80	599	54	62	471			
159	97	724	106	79	596	53	61	469			
158	97	721	105	79	594	52	60	466			
157	97	719	104	78	591	51	59	464			
156	97	717	103	77	589	50	58	462			
155	97	714	102	77	587	49	57	459			
154	97	712	101	77	584	48	55	457			
153	96	709	100	77	582	47	55	454			
152	96	707	99	76	579	46	53	452			
151	96	704	98	75	577	45	51	450			
150	96	702	97	74	575	44	48	447			
149	95	700	96	74	572	43	45	445			
148	95	697	95	74	570	42	42	442			
147	94	695	94	73	567	41	40	440			
146	94	692	93	72	565	40	37	438			
145	94	690	92	72	563	39	35	435			
144	94	688	91	71	560	38	32	433			
143	93	685	90	71	558	37	30	430			
142	93	683	89	71	555	36	27	428			
141	92	690	88	71	553	35	24	426			
140	92	678	87	71	551	34	22	423			
139	92	676	86	70	548	33	20	421			

CHAPTER VI

AUTOMOTIVE MECHANICS

A. EXPERIMENTAL TESTS

Tables VI-1 through VI-3 present test specifications, descriptions of the sample, and psychometric characteristics for the experimental tests. The subtest reliabilities as shown in Table VI-3 range from .51 to .85. Table VI-4 presents the intercorrelations and factor analysis for form A of the achievement test. All subtests, along with the Feeler Gauge, the Scope Dynamic, and the Tool Identification performance tests, load on factor 1 (see Appendix for a description of performance tests). This factor which accounts for 41 per cent of the common variance, is a measure of achievement in automotive mechanics.

Table VI-5 presents the intercorrelations and factor analysis for form B of the achievement test. All subtests, as well as the Mechanical Information, the Wide Range Vocabulary reference tests and the Tool Identification performance test, load on factor 1, which accounts for 39 per cent of the common variance. None of the achievement subtests load significantly on any of the other factors.

B. FINAL TESTS

Tables VI-6 and VI-7 present the description of the sample and psychometric characteristics of final tests. The reliabilities of the subtests range from .56 to .89, while the total test has a reliability of .97. None of the subtests are heavily skewed and all but the Power Train subtest are slightly platykurtic. The Power Train subtest is highly leptokurtic and not significantly skewed, suggesting that most students scored close to the middle of the distribution. The intercorrelations for the subtests are presented in Table VI-8. This would have the result of reducing the variance and would account for the low reliability.

Norms for converting raw scores to percentiles and standard scores are presented in Table VI-9 for the subtests and in Table VI-10 for the total test.

Table VI-1

AUTOMOTIVE MECHANICS OUTLINE

Test Specifications

CURRICULUM CONTENT AREA	K	U	A_k	A_u
I. TOOLS, SAFETY AND RELATED SCIENCE				
A. Care and use of tools				
1. Hand and power	16		2	
2. Measuring devices	1			
B. Shop and personal safety				
1. Use of power equipment	2	1		
2. Use of protective equipment	2		1	
3. Fire control and housekeeping	2			
C. Mathematics and physics	11	2	4	
II. ENGINES				
A. Fundamental types				
1. Construction	23	9	2	
2. Operating characteristics	23	9	5	1
B. Performance measures				
1. Testing procedures	2		3	
2. Output measurement	3		3	
C. Diagnosis of malfunctions				
1. Indications of trouble	1	6	2	
2. Use of electronic equipment	1			
3. Gauges and indicators			1	
D. Servicing and repair				
1. Minor adjustments	1	2	8	
2. Major overhaul	1		3	
3. Tools and equipment	2		1	
III. FUEL SYSTEMS				
A. Fundamental types	6	2		
B. Operating principles				
1. Fuel pumps and injection	5	5	2	
2. Carburization	4	6	1	
C. Testing and diagnosis				
1. Use of equipment	2		1	
2. Troubleshooting		5	4	
IV. ELECTRICAL SYSTEMS				
A. Operating fundamentals				
1. Power and circuit theory	22	5	1	
2. Timing and distributors	6	2	1	
3. Generators and ignition	22	8	1	
B. Diagnosis and service				
1. Problem areas	2	6	5	
2. Test equipment	11		8	
3. Repair	7	1	1	
V. CHASSIS AND SUSPENSION				
A. Fundamentals				
1. Springs and shocks	7	3		
2. Alignment	9	6	1	1

	K	U	A_k	A_u
B. Operating principles				
1. Steering mechanisms	2	1		
2. Stabilizer principles	3	5	1	
C. Service and repair				
1. Diagnosis of troubles		7	4	
2. Tool usage	7	1		
3. Alignment techniques	1	1	2	1
4. Steering and balancing	1		1	
VI. BRAKING SYSTEMS				
A. Fundamental types				
1. Drums and shoes	2	2		
2. Disc	1	2		
3. Hydraulic	4	1		
B. Operating principles				
1. Pressures, mechanical-hydraulic	2	4	7	1
2. Friction coefficients	3	3		
C. Diagnosis and service				
1. Indications of trouble and adjustments	4	5	8	
2. Drum, line and cylinder repair	2	1	1	
3. Tool and equipment usage	2			
VII. AIR CONDITIONING				
A. Fundamentals				
1. Heat absorption	2	1		
2. Evaporation - vaporization		3		
B. System operations				
1. Compressors	2	3	1	1
2. Valves, receivers	2	3	4	
C. Diagnosis, service and repair				
1. Cold spots		2		
2. Recharging and gases	2	3	1	
3. Measuring equipment		2		1
VIII. POWER TRAINS				
A. Fundamental systems				
1. Transmission				
a. Straight gear	1	2	2	
b. Automatic		5	1	2
2. Torque	1	2	1	
3. Differentials		5		
4. Clutches	2	4		
B. Operation				
1. Gear reductions and ratios	3	1		
2. Slip joints - splines	6	2		
3. Overdrives	3			
4. Universal		2		
C. Service, repair and test equipment				
1. Special tools	2	1		
2. Troubleshooting	2		1	
3. Techniques of assembly	1	2		
4. Clearance and specifications	1	1		
5. Testing techniques		1		

Table VI-2

AUTOMOTIVE MECHANICS
First Year

Description of Sample

State	No. of Inst.	No. of Students
Delaware	1	9
Georgia	1	12
New Jersey	3	40
North Carolina	22	219
South Carolina	9	82
	36	362

Table VI-3

AUTOMOTIVE MECHANICS

Experimental Tests
Description and Reliabilities

	Subtest	Time Limit (min)	No. of Items		Reliability	
			Form A	Form B	Form A	Form B
I	Tools, Safety, Related Science	15	19	18	.67	.51
II	Engines	50	53	53	.84	.85
III	Fuel Systems	15	20	20	.71	.70
IV	Electrical Systems	50	54	54	.83	.84
V	Chassis and Suspension	20	27	27	.71	.79
VI	Braking Systems	20	27	26	.82	.63
VII	Air Conditioning	15	16	16	.64	.71
VIII	Power Trains	20	26	26	.80	.59
		205	242	240		

Table VI-4

INTERCORRELATIONS AND FACTOR LOADINGS FOR AUTOMOTIVE MECHANICS

Experimental Test - Form A

	Intercorrelations																									Factor Loadings					
	Subtest								Reference Tests							Performance Tests															
	I	II	III	IV	V	VI	VII	VIII	MI	SM	Inf	CC	NC	WRV	SuD	FG	Mic	ScD	ScS	AuE	TI	D-KOR	D-NKOR	KOR sd	NKOR SD	1	2	3	4	5	h^2
I	--	61	56	63	47	57	36	51	38	22	39	31	08	25	31	33	-46	44	42	34	47	-17	11	-12	-01	64	37	21	08	19	63
II		--	76	71	66	66	38	65	48	07	48	30	09	32	38	47	-05	52	30	35	47	-18	11	-02	11	79	15	19	29	11	77
III			--	66	53	60	43	55	43	03	34	27	06	22	28	43	-07	32	24	48	46	-21	-17	-03	-01	78	04	23	08	08	67
IV				--	60	66	41	63	33	13	40	28	07	24	25	37	-17	29	22	26	47	02	-06	-01	-05	80	11	03	07	12	67
V					--	65	41	61	37	01	39	28	15	27	30	20	-06	41	11	12	31	04	-03	-06	-07	72	07	-01	13	10	55
VI						--	50	65	40	15	38	26	10	30	16	38	17	30	12	20	33	-01	-13	09	07	80	-11	-03	19	07	69
VII							--	40	11	-15	19	22	-14	15	05	21	01	27	19	27	18	-14	-20	09	04	61	-01	07	-03	-21	42
VIII								--	37	12	38	23	17	19	32	36	-06	37	18	09	44	-10	-41	05	02	78	-05	01	-04	23	67
MI									--	10	40	34	12	47	35	31	06	36	40	19	49	10	17	15	03	39	12	06	47	32	50
SM										--	09	11	22	-02	18	09	-28	17	-06	15	34	15	-21	-05	07	05	-04	00	-09	56	33
Inf											--	44	17	44	35	24	04	41	39	19	32	-11	33	04	10	36	22	19	51	20	51
CC												--	14	25	41	16	25	23	11	45	16	-28	01	-18	-19	24	-03	47	26	24	40
NC													--	09	19	-17	-26	37	17	-10	14	29	18	09	02	01	20	-17	11	47	30
WRV														--	17	23	08	-15	-04	09	23	06	30	04	07	23	06	-02	62	02	44
SuD															--	30	-18	40	29	42	37	-37	-17	-19	-16	25	14	49	03	44	52
FG																--	13	34	-01	34	36	-26	-03	04	04	44	-09	24	19	09	30
Mic																	--	-30	-68	57	-40	-27	-67	-10	46	-04	-90	30	24	-24	1.01
ScD																		--	39	16	24	03	13	09	00	39	32	10	04	39	42
ScS																			--	17	19	-19	26	-06	-09	21	70	23	00	12	60
AuE																				--	24	-24	-20	-31	14	26	-26	63	16	16	59
TI																					--	08	05	18	06	45	16	-02	16	45	46
D-KOR																						--		53		-07	-06	-71	05	27	59
D-NKOR																							--		18	-22	67	-11	53	-14	82
KOR sd																								--		08	-06	-60	11	13	40
NKOR sd																									--	-02	-23	-03	37	-09	20
% Var.																										41.5	17.3	16.0	12.7	12.5	
Cum. %																										41.5	58.8	74.8	87.5	100.0	

n = 183
Decimals omitted

Table VI-5

INTERCORRELATIONS AND FACTOR LOADINGS FOR AUTOMOTIVE MECHANICS

Experimental Test - Form B

	Intercorrelations																														
	Subtests								Reference Tests							Performance Tests										Factor Loadings					
	I	II	III	IV	V	VI	VII	VIII	MI	SM	Inf	CC	NC	WRV	SuD	FG	Mic	ScD	ScS	AuE	TI	D-KOR	D-NKOR	KOR sd	NKOR sd	1	2	3	4	5	h^2
I	--	65	53	55	49	51	20	40	40	01	37	23	26	35	21	33	56	23	22	40	48	15	05	09	-32	65	23	12	27	05	57
II		--	69	65	60	60	35	49	35	19	39	26	14	32	24	27	15	27	22	32	44	09	18	00	-17	77	-08	11	21	11	67
III			--	62	49	56	24	55	27	12	22	18	08	30	11	08	-09	07	05	46	43	30	05	06	-16	73	-03	16	-08	19	60
IV				--	63	70	42	58	37	11	33	23	15	35	23	23	-08	19	14	33	50	20	29	01	-25	81	-14	13	11	14	73
V					--	59	35	52	32	08	29	25	02	36	08	22	23	15	11	31	40	-05	00	00	-37	73	10	-02	09	01	56
VI						--	44	63	37	15	35	21	11	35	22	24	23	24	18	13	42	03	22	10	-17	80	-10	02	19	-04	68
VII							--	24	25	01	23	10	-17	11	-04	-05	-50	10	29	08	19	31	28	16	11	48	-33	26	-13	-20	46
VIII								--	28	16	26	17	18	19	22	22	05	13	10	44	50	06	-12	-10	-30	63	08	11	08	31	52
MI									--	06	43	22	11	38	21	24	46	30	06	10	42	20	-12	07	-25	48	28	09	18	-07	35
SM										--	15	07	11	19	-01	-07	-32	07	07	08	01	06	24	-30	-01	16	-16	01	-05	28	13
Inf											--	21	03	38	21	15	-01	19	05	00	20	06	-14	09	-42	45	19	08	08	-59	25
CC												--	18	14	39	32	68	25	08	06	12	-26	-07	14	-44	23	19	-07	62	-10	49
NC													--	03	21	15	-10	05	-11	17	03	04	-20	-43	-11	03	09	02	18	55	34
WRV														--	13	12	71	26	00	28	23	-07	-06	-18	-48	51	42	-16	08	01	46
SuD															--	47	-05	09	24	39	31	-03	24	11	-22	16	-12	21	57	21	45
FG																--	64	39	33	-10	22	-23	-19	-26	-17	13	18	-01	76	09	63
Mic																	--	02	-20	-39	47	-40	-32	06	-38	19	65	-48	51	-29	1.02
ScD																		--	40	47	28	60	-23	15	-18	17	26	62	23	06	54
ScS																			--	15	00	31	-21	60	-18	09	-02	64	29	-29	58
AuE																				--	46	42	-01	-07	03	32	00	48	-04	46	56
TI																					--	18	-30	-22	-46	53	38	12	10	25	52
D-KOR																						--		45		14	00	75	-29	-02	67
D-NKOR																							--		66	17	-81	-17	02	-05	71
KOR sd																								--		03	-06	46	03	-70	71
NKOR sd																									--	-29	-69	-06	-16	-01	59
																									% Var.	39.3	17.3	16.8	15.1	11.5	
																									Cum. %	39.3	56.6	73.4	88.5	100.0	

n = 176
Decimals omitted

Table VI-6

AUTOMOTIVE MECHANICS
Second Year

Description of Sample

State	No. of Inst.	No. of Stu.
Delaware	1	16
Georgia	10	72
New Jersey	2	25
North Carolina	26	268
Pennsylvania	2	38
South Carolina	9	97
Virginia	1	9
	51	525

Table VI-7

AUTOMOTIVE MECHANICS

Psychometric Characteristics
Final Test

Subtest		No. of Items	Time Limit	Reliability K-R (14)	Skewness	Kurtosis
I	Engines	60	55 min	89	-05	-58
II	Fuel Systems	30	25 min	80	-24	-74
III	Electrical Systems	45	40 min	88	08	-60
IV	Chassis and Suspensions	50	40 min	84	03	-38
V	Brakes	45	30 min	85	-17	-40
VI	Air Conditioning	25	20 min	87	-23	-63
VII	Power Trains	40	30 min	56	-02	3.08
	Total test			97	03	-02

Table VI-8

AUTOMOTIVE MECHANICS

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V	VI	VII	Total*
I	--	79	75	76	72	36	50	81
II		--	74	69	67	29	47	83
III			--	76	74	39	50	88
IV				--	75	47	56	90
V					--	48	55	88
VI						--	38	57
VII							--	65
Total								--

*Part-whole correlations
Decimals omitted

Table VI-9

RAW SCORE CONVERSIONS

AUTOMOTIVE MECHANICS SUBTESTS

Raw Score	1		2		3		4		5		6		7	
	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
59	99	723												
58	99	714												
57	99	704												
56	98	694												
55	97	684												
54	97	675												
53	95	665												
52	95	655												
51	93	646												
50	91	636												
49	89	626												
48	88	617					99	759						
47	86	607					99	747						
46	83	597					99	734						
45	79	587					99	722						
44	77	578			99	717	99	709	99	729				
43	73	568			99	705	98	696	99	716				
42	70	558			98	693	97	684	99	703				
41	67	549			97	682	96	671	99	690				
40	64	539			96	670	94	659	98	676				
39	61	529			94	658	93	646	97	663				
38	59	519			91	647	91	634	95	650				
37	55	510			89	635	88	621	91	637				
36	52	500			88	623	85	609	89	624				
35	49	490			86	611	83	596	87	611				
34	46	481			83	600	79	583	83	598			99	800
33	43	471			79	588	77	571	79	585			99	800
32	39	461			76	576	73	558	75	572			99	800
31	36	451			75	565	69	546	72	559			99	800
30	31	442			72	553	66	533	68	546			99	800
29	27	432			68	541	60	521	64	533			99	800
28	25	422	99	691	64	530	56	508	59	520			99	800
27	21	413	99	672	60	518	51	495	54	507			99	800
26	19	403	97	654	56	506	47	483	49	493			99	800
25	16	393	94	636	52	494	41	470	45	480	99	740	99	800
24	14	383	90	618	48	483	37	458	42	467	99	723	99	785
23	11	374	84	600	43	471	33	445	35	454	99	707	99	759
22	9	364	78	581	39	459	29	433	31	441	99	690	99	733
21	9	354	71	563	35	448	25	420	27	428	97	674	99	708
20	7	345	66	545	30	436	21	408	21	415	96	657	99	682
19	6	335	60	527	23	424	18	395	18	402	94	640	99	656
18	5	325	55	509	21	412	14	382	15	389	91	624	95	631
17	3	316	49	491	18	401	11	370	12	376	87	607	92	605
16	2	306	41	472	17	389	8	357	10	363	84	590	85	579
15	1	296	37	454	13	377	6	345	8	350	79	574	75	553
14	1	286	31	436	10	366	4	332	6	337	74	557	65	528
13	1	277	25	418	9	354	3	320	5	324	67	540	54	502
12	1	267	20	400	6	342	2	307	3	310	59	524	41	476
11	1	257	16	381	4	330	1	294	2	297	50	507	31	451
10	1	248	12	363	2	319	1	282	2	284	44	491	23	425
9	1	238	8	345	2	307	1	269	1	271	38	474	16	399
8	1	228	6	327	1	295	1	257	1	258	33	457	12	374
7	1	218	4	309	1	284	1	244	1	245	28	441	8	348
6	1	209	2	291	1	272	1	232	1	232	24	424	5	322
5	1	200	1	272	1	260	1	219	1	219	21	407	3	296
4	1	200	1	254	1	248	1	207	1	206	19	391	2	271
3	1	200	1	236	1	237	1	200	1	200	16	374	2	245
2					1	225	1	200	1	200	15	357	1	219
1					1	213	1	200	1	200	13	341	1	200

2

Table VI-10

RAW SCORE CONVERSIONS

AUTOMOTIVE MECHANICS TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
256	99	742	202	84	611	148	45	480	94		349
255	99	740	201	84	609	147	43	477	93	6	346
254	99	737	200	84	606	146	42	475	92	6	344
253	99	735	199	83	604	145	41	472	91	5	341
252	99	732	198	83	601	144	40	470	90	5	339
251	99	730	197	82	599	143	39	468	89	4	336
250	99	728	196	82	596	142	38	465	88	4	334
249	99	725	195	81	594	141	37	463	87	4	331
248	99	723	194	80	592	140	36	460	86	4	329
247	99	720	193	79	589	139	36	458	85	3	327
246	99	718	192	79	587	138	35	455	84	3	324
245	99	715	191	78	584	137	34	453	83	3	322
244	99	713	190	77	582	136	34	451	82	3	319
243	99	711	189	77	579	135	33	448	81	3	317
242	99	708	188	76	577	134	32	446	80	2	314
241	99	706	187	75	575	133	30	443	79	2	312
240	98	703	186	74	572	132	29	441	78	2	310
239	98	701	185	74	570	131	29	438	77	2	307
238	98	698	184	73	567	130	27	436	76	1	305
237	98	696	183	72	565	129	27	434	75	1	302
236	98	694	182	72	562	128	27	431	74	1	300
235	98	691	181	70	560	127	25	429	73	1	297
234	97	689	180	69	557	126	24	426	72	1	295
233	97	686	179	69	555	125	24	424	71	1	293
232	97	684	178	68	553	124	23	421	70	1	290
231	97	681	177	67	550	123	22	419	69	1	288
230	97	679	176	67	548	122	22	417	68	1	285
229	96	677	175	66	545	121	21	414	67	1	283
228	96	674	174	65	543	120	20	412	66	1	280
227	96	672	173	65	540	119	20	409	65	1	278
226	96	669	172	64	538	118	19	407	64	1	276
225	96	667	171	63	536	117	18	404	63	1	273
224	95	664	170	63	533	116	18	402	62	1	271
223	95	662	169	62	531	115	18	400	61	1	268
222	94	660	168	61	528	114	17	397	60	1	266
221	94	657	167	61	526	113	17	395	59	1	263
220	94	655	166	60	523	112	17	392	58	1	261
219	93	652	165	60	521	111	16	390	57	1	259
218	93	650	164	59	519	110	15	387	56	1	256
217	92	647	163	58	516	109	14	385	55	1	254
216	91	645	162	57	514	108	13	383	54	1	251
215	91	643	161	56	511	107	12	380	53	1	249
214	91	640	160	55	509	106	11	378	52	1	246
213	90	638	159	54	506	105	11	375	51	1	244
212	89	635	158	53	504	104	11	373	50	1	242
211	88	633	157	52	502	103	11	370	49	1	239
210	88	630	156	50	499	102	10	368	48	1	237
209	88	628	155	50	497	101	10	366	47	1	234
208	87	626	154	49	494	100	9	363	46	1	232
207	87	623	153	48	492	99	8	361	45	1	229
206	86	621	152	48	489	98	8	358	44	1	227
205	86	618	151	47	487	97	7	356	43	1	225
204	85	616	150	47	485	96	7	353	42	1	222
203	85	613	149	46	482	95	7	351			

CHAPTER VII

MACHINIST

A. EXPERIMENTAL TESTS

Tables VII-1 through VII-3 present test specifications, the description of the sample, and the psychometric characteristics for the experimental tests. From Table VII-3 it can be seen that the reliabilities of the subtests range from .09 to .85. Table VII-4 presents the intercorrelations and factor analysis for form A of the experimental test. All subtests, as well as the Mechanical Information and the Inference reference tests and the Micrometer performance test, load on factor 1. As this factor accounts for 43 per cent of the common variance and explains virtually all of the intercorrelations among the achievement tests, it can be concluded that the subtests are measuring a common dimension of achievement in the Machinist trade. Table VII-5 presents the intercorrelations and factor analysis for form B. All subtests, as well as the Micrometer, the Indexing, and the Truing performance tests, load on factor 1. This factor accounts for 34 per cent of the common factor variance and can be considered as measuring a common dimension of achievement.

B. FINAL TEST

Tables VII-6 through VII-8 present the description of the sample, the psychometric characteristics, and the intercorrelations for the final test. From Table VII-7 it can be seen that the reliabilities of the total test is .95, with subtest reliabilities ranging from .31 to .87. None of the subtests are skewed and are essentially mesokurtic. The total test is slightly positively skewed and is mesokurtic. The intercorrelations presented in Table VII-8 show that the subtests are homogeneous with respect to shared variance.

Tables VII-9 and VII-10 present conversions from raw scores to percentiles and standard scores for subtests and total tests respectively.

Table VII-1

MACHINIST TRADE

Test Specifications

CURRICULUM CONTENT AREA	K	U	A_k	A_u
I. SAFETY PROCEDURES				
A. Personal	5	2	3	
B. Shop	5	1		
II. HAND TOOLS AND APPLICATIONS				
A. Hand tools	7	6	5	
B. Cutting tools	4		1	
C. Taps, drills, reamers	8		3	
D. Files and processes	6	1	3	
III. MEASURING TOOLS AND PROCESSES				
A. Layout and planning	18	6	11	
B. Indirect measurement	4	2	1	
C. Direct measurement	15	7	9	
D. Electrolimit gauges	4	2		
E. Optical flats	1	1		
F. Mathematics	7	3	49	
G. Blue print reading	3	9	3	7
IV. CUTTING TOOLS				
A. Geometry and theory	17	21	12	1
B. Cutting steels and alloys		1		
C. Carbides and ceramics		2	1	
V. MILLING MACHINES				
A. Horizontal	10	11	12	
B. Vertical	1		4	
C. Universal	2	6	7	
D. Feeds and speeds			2	
VI. LATHES				
A. Standard engine - tool room	31	19	23	2
B. Turret and screw machines	1	2	2	
C. Formulae and math	2	1	4	
VII. GRINDING MACHINES				
A. Safety procedures		2	3	
B. Bench and tool grinding	2	1	2	
C. Surface grinding		1	3	
D. Cylindrical grinding	2	3	9	
E. Centerless grinding		2	1	
F. Wheels, types and identification	12	7	2	
VIII. MINOR MACHINES				
A. Drill press	9	4	11	
B. Shaper, planer	2	2	6	
C. Power cutoff	1	1	2	
D. Numerical control machines	5		3	
IX. METALLURGY				
A. Composition of metals	8	6	1	
B. Application - choosing metal for job	5	1	3	
C. Heat treatment	2	8	7	

Table VII-2

MACHINIST
First Year

Description of Sample

State	No. of Inst.	No. of Students
Delaware	1	11
Georgia	1	9
New Jersey	3	35
North Carolina	11	118
South Carolina	23	67
	23	240

Table VII-3

MACHINIST
Experimental Tests

Description and Reliabilities

	Subtest	Time Limit (min)	No. of Items Form A	No. of Items Form B	Reliability Form A	Reliability Form B
I	Safety Procedure	10	14	13	.55	.09
II	Hand Tools & Application	20	22	22	.63	.64
III	Measuring Tools & Processes	70	83	84	.85	.77
IV	Cutting Tools	20	27	26	.68	.57
V	Lathes	40	42	41	.83	.78
VI	Milling Machines	20	26	26	.63	.67
VII	Grinding Machines	20	25	25	.60	.68
VIII	Metallurgy	20	20	21	.60	.51
IX	Minor Machines	20	23	23	.70	.66
		240	282	281		

Table VII-4

INTERCORRELATIONS AND FACTOR LOADINGS FOR MACHINIST

Experimental Test - Form A

	Intercorrelations																													
	Subtest									Reference Tests							Performance Tests								Factor Loadings					
	I	II	III	IV	V	VI	VII	VIII	IX	MI	SM	Inf	CC	Shd	WRV	SuD	FG	Mic	Ind	Tru	KOR	NKOR	KORsd	NKORsd	1	2	3	4	5	h^2
I	--	52	48	42	43	61	49	24	48	35	10	37	22	26	04	14	21	47	21	-25	17	17	03	-45	68	04	09	15	-01	49
II		--	56	44	46	46	51	34	50	30	-04	26	06	10	15	08	25	23	15	-29	08	26	-18	-35	66	11	16	-02	-16	50
III			--	67	68	66	51	40	57	48	-01	35	22	39	13	28	32	38	16	-27	14	14	17	-46	76	19	03	17	14	66
IV				--	58	47	49	35	44	38	-01	28	23	32	13	30	36	42	12	-41	30	-11	18	-24	61	13	06	33	20	54
V					--	64	58	42	56	50	-12	30	17	16	13	20	22	45	05	-18	32	06	18	-31	74	07	02	11	20	61
VI						--	64	45	57	42	-07	38	26	28	00	16	54	37	15	-28	34	03	17	-35	75	20	-01	16	16	65
VII							--	41	59	43	24	40	21	28	18	15	52	35	24	-14	32	36	08	-17	71	29	25	00	02	65
VIII								--	45	25	-01	34	-01	16	16	10	25	50	07	-33	17	-12	-08	-45	59	03	-07	13	-05	37
IX									--	37	11	31	05	04	06	08	-05	43	-01	-14	29	31	-02	-29	77	-09	15	-08	-04	63
MI										--	03	47	15	33	30	30	32	-01	12	-34	31	16	21	-23	47	36	18	05	26	45
SM											--	00	-12	09	07	-21	-20	-01	-07	00	03	22	-42	08	10	-03	20	-25	-32	21
Inf												--	26	32	27	25	43	41	-09	-17	-02	06	20	-09	41	38	01	22	02	36
CC													--	22	09	37	54	49	10	-16	-12	-18	-03	-13	13	21	-08	65	-07	49
ShD														--	13	35	70	18	27	-20	-02	-16	42	-31	21	53	-12	33	31	55
WRV															--	13	54	-18	07	-34	-04	27	17	13	05	59	31	-04	01	45
SuD																--	30	37	-11	-28	29	02	-08	14	12	14	13	57	10	39
FG																	--	02	-20	-03	-48	-06	-09	10	19	89	-14	32	-16	98
Mic																		--	09	-21	04	06	-20	-45	54	-23	-05	53	-17	66
Ind																			--	-32	24	51	27	15	09	-06	54	09	28	39
Tru																				--	-14	-26	20	-25	-22	-08	-51	-34	04	43
KOR																					--	00	59	00	29	-31	25	-03	65	66
NKOR																						--	00	45	12	06	75	-19	-13	63
KOR sd																							--	00	02	15	-01	-09	85	76
NKOR sd																								--	-54	13	54	-02	-03	61
% Var.																									43.1	16.5	13.9	13.3	13.2	
Cum. %																									43.1	59.6	73.5	86.7	100.0	

n = 132
Decimals omitted

Table VII-5

INTERCORRELATIONS AND FACTOR LOADINGS FOR MACHINIST

Experimental Test - Form B

	Intercorrelations																													
	Subtests									Reference Tests							Performance Tests								Factor Loadings					
	I	II	III	IV	V	VI	VII	VIII	IX	MI	SM	Inf	CC	ShD	WRV	Sud	FG	Mic	Ind	Tru	D-KOR	D-NKOR	KOR sd	NKOR sd	1	2	3	4	5	h^2
I	--	35	35	42	37	32	22	33	40	30	01	28	12	15	13	19	41	31	26	-27	-12	18	32	24	44	17	31	08	-05	33
II		--	46	60	67	39	45	43	63	23	-13	08	19	34	12	36	05	33	39	-52	00	-28	34	17	73	24	-07	-01	10	60
III			--	58	61	57	30	29	45	41	06	32	38	44	32	40	25	41	33	-37	10	08	47	15	49	50	14	20	02	55
IV				--	73	52	39	25	65	40	-15	26	21	25	37	34	56	44	35	-43	00	-24	39	16	66	41	26	-02	06	68
V					--	60	54	41	69	40	-05	38	36	34	43	50	56	36	21	-57	14	-09	46	31	70	43	22	21	13	78
VI						--	52	38	52	34	14	30	23	32	34	30	42	31	31	-44	04	-27	35	38	57	38	06	27	-06	56
VII							--	49	57	19	08	06	-06	-06	23	08	-10	24	28	-50	10	05	16	40	75	-13	-09	16	04	61
VIII								--	44	17	10	17	03	04	30	12	03	13	25	-40	-03	25	21	26	59	-07	07	18	02	39
IX									--	25	-17	24	15	13	32	39	40	34	18	-42	12	14	41	43	76	11	24	17	22	71
MI										--	-07	33	18	34	37	32	43	50	39	-38	11	-45	47	-49	30	64	16	-22	02	58
SM											--	04	05	09	-04	04	01	25	16	-21	-38	15	-55	21	01	17	-06	21	-70	54
Inf												--	24	33	42	39	30	-14	-02	-07	-01	53	17	67	07	28	28	70	04	66
CC													--	23	27	53	22	23	14	-16	20	-48	25	-29	03	68	-06	01	04	47
ShD														--	21	20	43	14	11	-07	-01	-16	53	36	07	53	11	36	01	42
WRV															--	26	53	12	14	-17	16	08	36	44	24	33	25	38	12	39
SuD																--	04	09	27	-28	28	-20	46	-32	22	60	-03	03	22	46
FG																	--	00	-16	25	-19	1.0	05	00	06	27	1.07	12	-05	1.25
Mic																		--	34	-53	-10	-17	-32	20	50	25	-05	-11	-46	53
Ind																			--	-15	-19	-16	05	-16	39	27	-08	-16	-22	30
Tru																				--	10	13	-24	00	-67	-18	18	03	13	54
D-KOR																					--	00	57	00	-01	12	-14	09	66	48
D-NKOR																						--	00	38	-06	-51	82	39	00	1.09
KOR sd																							--	00	27	41	07	13	72	78
NKOR sd																								--	31	-28	02	86	-09	92
% Var																									33.7	22.7	16.4	14.3	12.9	
Cum. %																									33.7	56.4	72.8	87.1	100.0	

n = 177
Decimals omitted

Table VII-6

MACHINIST
Second Year

Description of Sample

State	No. of Inst.	No. of Students
Delaware	1	13
Georgia	10	62
New Jersey	2	26
North Carolina	12	104
Pennsylvania	2	11
South Carolina	9	102
Virginia	1	14
	37	332

Table VII-7

MACHINIST

Psychometric Characteristics
Final Test

Subtest	No. of Items	Time Limit	Reliability K-R (14)	Skewness	Kurtosis
I Hand Tools and Application	25	25 min	65	25	-57
II Measuring Tools and Processes	80	70 min	87	04	-55
III Cutting Tools	30	25 min	72	-12	-26
IV Milling Machines	30	25 min	75	15	-43
V Lathes	40	35 min	82	02	-70
VI Grinding Machines	30	20 min	80	15	-54
VII Minor Machines	25	20 min	65	-07	02
VIII Metallurgy	25	20 min	31	-54	90
Total test			95	20	-02

Table VII-8

MACHINIST

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V	VI	VII	VIII	Total*
I	--	47	56	49	55	52	35	31	66
II		--	63	70	67	59	53	41	88
III			--	62	63	65	47	46	81
IV				--	74	64	50	46	85
V					--	64	45	44	85
VI						--	56	44	81
VII							--	36	67
VIII								--	57
Total									--

*Part-whole correlations
Decimals omitted

Table VII-9

RAW SCORE CONVERSIONS

MACHINIST SUBTEST

	1		2		3		4		5		6		7		8	
Raw Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
68			99	757												
67			99	748												
66			99	739												
65			99	730												
64			99	721												
63			98	712												
62			98	703												
61			98	694												
60			97	684												
59			97	675												
58			96	666												
57			95	657												
56			95	648												
55			93	639												
54			91	630												
53			88	621												
52			86	612												
51			84	603												
50			81	594												
49			78	584												
48			78	575												
47			75	566												
46			71	557												
45			68	548												
44			65	539												
43			62	530												
42			58	521												
41			53	512												
40			51	503												
39			48	494												
38			46	484					99	735						
37			43	475					99	720						
36			40	466					99	705						
35			36	457					98	690						
34			35	448					98	675						
33			31	439					95	661						
32			28	430					92	646						
31			25	421					90	631						
30			21	412					86	616						
29			19	403			99	748	84	601						
28			16	394			99	728	80	587	99	742				
27			14	384	99	742	97	709	76	572	99	724				
26			12	375	99	722	97	689	72	557	98	706				
25			12	366	99	701	95	669	67	542	97	688				
24			9	357	98	681	94	649	62	528	96	670				
23			7	348	96	661	91	629	58	513	94	652	99	800		
22	99	771	6	339	93	640	86	609	52	498	91	634	99	800		
21	99	744	4	330	88	620	81	589	47	483	88	615	99	788		
20	99	717	3	321	85	600	79	570	42	468	84	597	99	763		
19	98	690	2	312	81	579	73	550	37	454	79	579	99	738		
18	96	663	2	303	75	559	67	530	32	439	72	561	99	712		
17	91	637	1	294	67	539	59	510	28	424	68	543	98	687		
16	86	610	1	284	59	518	50	490	23	409	62	525	96	662		
15	79	583	1	275	51	498	43	470	18	394	57	507	94	637	99	755
14	74	556	1	260	45	478	36	451	15	380	52	488	89	612	99	716
13	66	529			37	458	29	431	9	365	45	470	82	586	98	678
12	58	502			30	437	22	411	7	350	39	452	76	561	94	639
11	50	475			24	417	17	391	4	335	32	434	69	536	91	601
10	39	448			20	397	12	371	3	320	26	416	57	511	81	562
9	30	422			14	376	9	351	2	306	19	398	49	486	67	524
8	19	395			9	356	6	332	1	291	14	379	40	460	47	485
7	9	368			5	336	2	312	1	276	7	361	28	435	33	447
6	5	341			3	315	1	292	1	261	4	343	21	410	18	408
5	2	314			1	295	1	272	1	246	2	325	13	385	12	370
4	1	287			1	275	1	252			1	307	10	360	7	332
3	1	260			1	254					1	289	6	335	4	293
2	1	233			1	234					1	271	4	309	2	255
1					1	214					1	252	3	284	2	216

Table VII-10

RAW SCORE CONVERSIONS

MACHINIST TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
224	99	748	170	80	592	116	30	437	62	1	281
223	99	745	169	79	590	115	29	434	61	1	278
222	99	742	168	78	587	114	28	431	60	1	275
221	99	740	167	78	584	113	27	428	59	1	272
220	99	737	166	77	581	112	26	425	58	1	269
219	99	734	165	76	578	111	25	422	57	1	267
218	99	731	164	76	575	110	24	419	56	1	264
217	99	728	163	76	572	109	23	417	55	1	261
216	99	725	162	75	569	108	21	414	54	1	258
215	99	722	161	74	567	107	21	411			
214	99	719	160	73	564	106	20	408			
213	99	716	159	72	561	105	19	405			
212	99	714	158	71	558	104	19	402			
211	99	711	157	70	555	103	18	399			
210	99	708	156	69	552	102	18	396			
209	98	705	155	69	549	101	16	393			
208	98	702	154	67	546	100	15	391			
207	98	699	153	66	543	99	14	388			
206	98	696	152	64	541	98	13	385			
205	97	693	151	64	538	97	11	382			
204	97	691	150	63	535	96	11	379			
203	96	688	149	63	532	95	10	376			
202	96	685	148	62	529	94	9	373			
201	96	682	147	62	526	93	8	370			
200	96	679	146	61	523	92	6	367			
199	95	676	145	60	520	91	6	365			
198	94	673	144	59	517	90	5	362			
197	94	670	143	58	515	89	5	359			
196	94	667	142	57	512	88	5	356			
195	94	665	141	56	509	87	4	353			
194	94	662	140	56	506	86	4	350			
193	94	659	139	56	503	85	4	347			
192	94	656	138	55	500	84	4	344			
191	93	653	137	53	497	83	4	342			
190	92	650	136	52	494	82	4	339			
189	92	647	135	51	492	81	3	336			
188	92	644	134	50	489	80	3	333			
187	91	642	133	47	486	79	3	330			
186	90	639	132	46	483	78	3	327			
185	89	636	131	45	480	77	3	324			
184	88	633	130	44	477	76	3	321			
183	88	630	129	43	474	75	2	318			
182	86	627	128	43	471	74	2	316			
181	86	624	127	42	468	73	1	313			
180	84	621	126	42	466	72	1	310			
179	84	618	125	40	463	71	1	307			
178	84	616	124	38	460	70	1	304			
177	83	613	123	38	457	69	1	301			
176	83	610	122	36	454	68	1	298			
175	83	607	121	35	451	67	1	295			
174	82	604	120	34	448	66	1	293			
173	82	601	119	34	445	65	1	290			
172	81	598	118	32	442	64	1	287			
171	80	595	117	30	440	63	1	284			

CHAPTER VIII

AIR CONDITIONING, HEATING AND REFRIGERATION

A. EXPERIMENTAL TEST

Tables VIII-1 through VIII-3 present test specifications, descriptions of the sample and detailed psychometric characteristics for the experimental Air Conditioning, Heating and Refrigeration tests. From Table VIII-3 it can be seen that the reliabilities of the experimental subtests range from .45 to .86. Table VIII-4 presents the intercorrelations and factor analysis results. It can be seen that factor I, which accounts for 48 per cent of the common variance, explains most of the correlations among the achievement subtests. Subtests I through IV and VI have very high loadings on factor 1, while subtests V and VII have moderate loadings on this factor. Among the reference tests, mechanical information and inference load moderately on factor 1. Thus, mechanical knowledge and general reasoning seem to be relevant abilities related to successful performance on this achievement test. Several of the reference tests load significantly on factor 4, although this factor is unrelated to performance on the achievement tests.

B. FINAL TEST

The description of the final sample is presented in Table VIII-5, and the psychometric characteristics of this test are presented in Table VIII-6. It can be seen from this table that the reliability of the subtests ranged from .62 to .89, with the total test having a reliability of .95. It can also be seen that skewness is not large for any of the subtests except number II, which is negatively skewed. Kurtosis is not large for any of the subtests except number II and the total test. Both are leptokurtic, meaning that the students' scores cluster about the mean to a greater degree than normal. From the intercorrelations in Table VIII-7 it can be seen that the subtests have moderate to high intercorrelations.

Norms for converting raw scores to percentiles and standard scores are presented in Table VIII-8 for subtests and Table VIII-9 for total test scores.

Table VIII-1

AIR CONDITIONING, HEATING, AND REFRIGERATION

Test Specifications

CURRICULUM CONTENT AREA	K	U	A_k	A_u
I. PRINCIPLES OF REFRIGERATION				
A. Basic terminology	12	5	3	1
1. Heat and temperature	2	1		
2. British thermal unit	2		2	
3. Specific heat			4	
4. Gauge pressure	1		2	
5. Absolute pressure	1		1	
6. Superheat	1			
7. Methods of heat transfer	1	1	2	
8. Matter and energy	2		1	
B. Temperature, pressure, volume	6	2		1
1. Charles' Law	2	1	1	
2. Dalton's Law	1	1		
3. Boyle's Law	1			
4. Evaporation and condensation	1	3		
C. Mechanical refrigeration cycles	9	5	4	
1. Compression	3	13	2	
2. Absorption	8	6	3	
II. REFRIGERATION APPLICATIONS				
A. Hermetic compressor		1		
1. Reciprocating	1		2	
2. Rotary	2	1		
B. Capillary tube	3	2	2	
C. Evaporators	1			
1. Gravity				
2. Forced convected				
3. Liquid and air cooling			1	
D. Condensers				
1. Gravity		3	1	
2. Forced convected	3	1		
3. Air and water cooled	4	2	3	1
E. Motors		1		
1. Shaded pole		2		
2. Split phase	1			
3. Capacitor start	6	7	2	2
4. Induction		1		
F. Controls				
1. Thermostats and defrost	3	4	1	
2. Relays	1	2	1	
3. Overloads	1	2		
G. Installation and service problems				
1. Leaks, fans, pumps, piping	8		11	
2. Compressor, motors	4	9	6	1
3. Defrosting, draining, moisture		8	4	3

		K	U	A_k	A_u
H.	Equipment selection		3	4	
1.	Floats and coils	5	5	4	
2.	Capillary tubes and expansion valves	5	3	1	2
3.	Evaporators and condensers	3	7	6	1
I.	Commercial system accessories	5	10	3	2
1.	Vibration eliminators				
2.	Oil separators	2			
3.	Pressure regulators	1	1		
4.	Solenoid and check valve	1	1	1	
III.	CONTROLS				
A.	Instrumentation				
1.	Sensing element	4	4	2	
2.	Controller	2	3		
3.	Actuator	1	1	1	
B.	Control circuit electricity	2	4		
1.	Voltage, current, resistance	3	1		
2.	Ohm's Law	1	1	1	
3.	Power	3	2		
4.	Transformers				
5.	Electromagnetism	1			
6.	Parallel and series circuits	1	1	1	
C.	Electric systems	6	5	3	4
D.	Pneumatic systems	6	3	1	1
IV.	AIR CONDITIONING AND HEATING				
A.	Heating				
1.	Warm air	2	4		1
2.	Hot water	2		1	
3.	Steam	1	2	1	
4.	Heat pump	2		1	
5.	Fuels and burners	10	6	3	2
B.	Cooling				
1.	Direct expansion	7	6	1	
2.	Chilled water	1	8		
3.	Absorption	3	2		
C.	Installation and service problems				
1.	Fuels and burners	9	12	6	1
2.	Blowers, motors, and static pressure	2	5	1	
3.	Pumps, pipe and head	1	3	1	
4.	Hydronic accessories			3	
5.	Duct fabrication and installation		3		
6.	Furnace, boiler and heat pump		4	1	
7.	Electric heating elements	3	1	2	
8.	Defrost controls, metering devices	4	3		
9.	Compressor, condenser, evaporator		4	5	2
D.	Properties of air and the psychometric chart				
1.	Absolute temperature and pressure		1		
2.	Temperature, pressure, and volume	1	1	1	
3.	Density and specific volume	1	1	1	1
4.	Standard air	2		1	
5.	Dry bulb, wet bulb and dew point	5	3	2	3
6.	Humidity ratio - degree saturation	2	2		
7.	Sensible heat ratio	2	2	2	5

	K	U	A_k	A_u
E. Heat loss and gain				
1. Design and conditions	2	1		
2. U factors			1	
3. Conduction, infiltration and ventilation	2	1		
4. Internal and solar gains	2			
F. Systems design				
1. Air	9	1	2	
2. Water	5		3	3
3. Steam				
V. BLUEPRINT READING AND ESTIMATING				
A. Mechanical print reading				
1. Orthographic and isometric interpretation	2	6		
2. Three-dimensional layouts	6	4		
B. Plans and specifications	2	3		
1. Drawing symbols and abbreviations	7	1		
2. General and mechanical	5	1	1	
C. Take-off procedures				
1. Equipment, material, labor	1	2		
VI. MATERIALS, TOOLS AND SAFETY				
A. Refrigerants				
1. Class I, II, III	5	3		
B. Refrigerant Oils	3	1		
C. Copper tube and fitting and valves	7	3		
D. Pipe and fittings and valves	3	3		
E. Sheet metal, pipe and duct insulation	6	2	1	
F. Pipe cutter, threaders, reamers	3	2		
G. Sheet metal hand tools and shop equip.	12	3		
H. Refrigerant hand tools	6	2		
I. Safety				
1. Hand tools	1			
2. Shop equipment		1		
3. Refrigerant	1	4		
4. Electrical		3	1	
5. On-the-job practice	2	2		

Table VIII-2

AIR CONDITIONING, HEATING AND REFRIGERATION
First Year

Description of Sample

State	No. of Inst.	No. of Stu.
Georgia	1	10
North Carolina	6	53
South Carolina	9	89
	16	152

Table VIII-3

AIR CONDITIONING, HEATING AND REFRIGERATION
Experimental Tests

Description and Reliabilities

Subtest	Time Limit (min)	No. of Items	Reliability
I. Fundamentals	35	44	.75
II Refrigeration	65	75	.86
III Air Conditioning	65	76	.83
IV Controls	30	40	.80
V Blueprint reading	20	25	.86
VI Materials, Tools and Equipment	15	20	.65
VII Estimating Controls	15	20	.45
	245	300	

Table VIII-4

AIR CONDITIONING, HEATING AND REFRIGERATION

Intercorrelations and factor loadings

	Intercorrelations																		
	Subtests							Reference Tests							Factor Loadings				
	I	II	III	IV	V	VI	VII	MI	SM	Inf	CC	WRV	SuD	FC	1	2	3	4	h^2
I	--	70	72	63	35	61	41	42	03	33	09	34	24	05	80	-07	-10	19	69
II		--	78	61	39	59	48	49	-07	33	02	28	18	-12	82	-14	-27	13	78
III			--	69	46	64	53	39	04	37	06	40	18	03	87	-02	-13	16	80
IV				--	53	61	52	27	18	45	12	36	26	04	80	17	05	22	72
V					--	38	42	25	03	35	33	22	34	18	51	14	24	43	52
VI						--	47	34	03	28	-08	27	10	12	85	-04	07	-02	73
VII							--	24	10	39	16	31	16	-08	62	22	-07	21	48
MI								--	13	32	07	39	11	-25	37	09	-66	32	68
SM									--	08	15	05	-07	-02	05	87	-09	-05	77
Inf										--	35	46	24	21	36	21	05	62	56
CC											--	14	23	14	-07	44	16	61	60
WRV												--	38	15	28	-07	-18	66	55
SuD													--	10	09	-26	04	72	60
FC														--	06	-03	82	21	72
													% Var.		48.2	13.0	14.7	24.1	
													Cum. %		48.2	61.2	75.9	100.0	

n = 152
Decimals omitted

Table VIII-5

AIR CONDITIONING, HEATING AND REFRIGERATION
Second Year

Description of Sample

State	No. of Inst.	No. of Stu.
Georgia	8	46
North Carolina	8	73
Pennsylvania	1	7
South Carolina	8	62
Virginia	1	16
	26	204

Table VIII-6

AIR CONDITIONING, HEATING AND REFRIGERATION

Psychometric Characteristics
Final Test

	Subtest	No. of Items	Time Limit	Reliability K-R (14)	Skewness	Kurtosis
I	Principles of Refrigeration	30	30 min	71	-23	23
II	Refrigeration Applications	60	60 min	83	-79	1.68
III	Controls	30	30 min	72	34	-04
IV	Air Conditioning	80	75 min	89	23	-38
V	Blueprint Reading and Estimating	25	25 min	70	-25	-26
VI	Materials, Tools and Safety	25	20 min	62	-14	59
	Total test			95	10	1.24

Table VIII-7

AIR CONDITIONING, HEATING AND REFRIGERATION

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V	VI	TOTAL*
I	--	74	60	64	40	45	81
II		--	61	62	32	47	83
III			--	74	42	43	81
IV				--	48	60	91
V					--	35	58
VI						--	67
Total							--

*Part-whole correlations
Decimals omitted

Table VIII-8

RAW SCORE CONVERSIONS

AIR CONDITIONING, HEATING AND REFRIGERATION SUBTEST

Raw Score	1		2		3		4		5		6	
	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
69							99	778				
68							99	770				
67							99	761				
66							99	753				
65							99	744				
64							99	735				
63							99	727				
62							99	718				
61							99	710				
60							98	701				
59							98	693				
58							97	684				
57							96	675				
56							95	667				
55							93	658				
54							92	650				
53			99	721			90	641				
52			99	710			88	633				
51			99	699			86	624				
50			99	687			84	616				
49			98	676			83	607				
48			97	665			82	598				
47			96	653			80	590				
46			96	642			77	581				
45			94	631			75	573				
44			91	619			73	564				
43			89	608			72	556				
42			85	596			70	547				
41			81	585			68	538				
40			79	574			65	530				
39			75	562			63	521				
38			68	551			61	513				
37			63	540			58	504				
36			60	528			53	496				
35			54	517			50	487				
34			51	506			48	478				
33			47	494			43	470				
32			44	483			39	461				
31			37	472			35	453				
30			33	460			31	444				
29			29	449	99	800	28	436				
28			26	438	99	800	26	427				
27	99	716	21	426	99	783	24	418				
26	99	693	19	415	99	761	22	410				
25	98	670	16	404	99	739	18	401				
24	95	647	13	392	98	717	14	393				
23	89	625	11	381	97	695	12	384				
22	85	602	9	369	95	673	9	376	99	718		
21	80	579	7	358	94	651	8	367	99	693	99	777
20	72	556	5	347	91	629	7	358	98	668	99	748
19	65	533	5	335	86	606	5	350	94	644	99	719
18	58	511	4	324	83	584	3	341	89	619	97	690
17	51	488	3	313	77	562	2	333	85	595	97	662
16	40	465	2	301	72	540	2	324	79	570	94	633
15	33	442	1	290	62	518	1	316	70	545	86	604
14	27	420	1	279	53	496	1	307	60	521	81	575
13	19	397	1	267	44	474	1	298	53	496	75	546
12	10	374	1	256	38	452	1	290	41	471	63	518
11	7	351	1	245	29	429	1	281	30	447	51	489
10	4	328	1	233	21	407	1	273	25	422	39	460
9	2	306	1	222	17	385	1	264	19	398	28	431
8	1	283	1	211	9	363	1	256	13	373	18	402
7	1	260	1	200	5	341			10	348	9	373
6	1	237	1	200	3	319			5	324	7	345
5	1	215	1	200	1	297			2	299	3	316
4	1	200	1	200					1	274	2	287
3	1	200	1	200					1	250	1	258
2	1	200	1	200					1	225	1	229
1	1	200	1	200					1	200	1	201

Table VIII-9

RAW SCORE CONVERSIONS

AIR CONDITIONING, HEATING AND REFRIGERATION TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
204	99	760	155	81	596	106	25	432	57	1	268
203	99	756	154	81	593	105	24	429	56	1	265
202	99	753	153	80	589	104	22	426	55	1	262
201	99	750	152	80	586	103	22	422	54	1	258
200	99	746	151	78	583	102	21	419	53	1	255
199	99	743	150	77	579	101	20	416	52	1	252
198	99	740	149	76	576	100	19	412	51	1	248
197	99	736	148	76	573	99	19	409	50	1	245
196	98	733	147	75	569	98	19	405	49	1	242
195	98	730	146	74	566	97	17	402			
194	98	726	145	73	563	96	16	399			
193	98	723	144	71	559	95	16	395			
192	98	720	143	70	556	94	15	392			
191	98	716	142	70	553	93	15	389			
190	98	713	141	69	549	92	14	385			
189	98	710	140	68	546	91	13	382			
188	97	706	139	68	543	90	12	379			
187	97	703	138	67	539	89	10	375			
186	97	700	137	65	536	88	10	372			
185	97	696	136	64	532	87	9	369			
184	97	693	135	63	529	86	9	365			
183	97	690	134	61	526	85	8	362			
182	97	686	133	59	522	84	7	359			
181	96	683	132	58	519	83	6	355			
180	96	680	131	56	516	82	6	352			
179	96	676	130	55	512	81	5	349			
178	96	673	129	55	509	80	5	345			
177	95	670	128	54	506	79	5	342			
176	95	666	127	51	502	78	4	339			
175	95	663	126	51	499	77	4	335			
174	95	659	125	50	496	76	4	332			
173	94	656	124	49	492	75	4	329			
172	94	653	123	47	489	74	4	325			
171	94	649	122	47	486	73	2	322			
170	93	646	121	46	482	72	2	319			
169	93	643	120	44	479	71	2	315			
168	93	639	119	42	476	70	1	312			
167	92	636	118	40	472	69	1	309			
166	91	633	117	40	469	68	1	305			
165	89	629	116	39	466	67	1	302			
164	89	626	115	38	462	66	1	299			
163	88	623	114	36	459	65	1	295			
162	86	619	113	35	456	64	1	292			
161	85	616	112	34	452	63	1	289			
160	84	613	111	32	449	62	1	285			
159	83	609	110	30	446	61	1	282			
158	83	606	109	29	442	60	1	278			
157	83	602	108	28	439	59	1	275			
156	82	599	107	26	436	58	1	272			

CHAPTER IX

ELECTRICAL INSTALLATION AND MAINTENANCE

A. EXPERIMENTAL TESTS

Table IX-1 through IX-3 present test specifications, description of the sample, and psychomotive characteristics of the experimental tests. From Table IX-3 it can be seen that the reliabilities of the experimental subtests ranged from .61 to .85. The intercorrelations and factor analysis results for form A of the test are shown in Table IX-4. Subtest III, Construction Wiring, loads on factor 3 along with the Mechanical Information, Subtraction-Multiplication, and the Cube Comparison reference tests. All other achievement tests load on factor 1, which accounts for 47 per cent of the common variance and accounts for most of the correlations among the subtests. Subtest III, however, appears to be measuring a different dimension relying on abilities other than those required by the other subtests.

Table IX-5 presents the intercorrelations and factor analysis for form B. Subtests IV, VI, and VII load on factor 5, while Subtest V loads on factor 3. The fact that the subtests are spread across three factors gives an indication that the subtests are not measuring a common dimension of achievement as was true of form A.

B. FINAL TEST

Tables IX-6 through IX-8 present the description of the sample, the psychometric characteristics, and the intercorrelations of the final test. The reliabilities of the subtests range from .70 to .87, with the reliability of the total test being .94. The total test is slightly positively skewed indicating a tendency to score in the lower portion of the distribution. The total test distribution is also slightly platykurtic. The intercorrelations in Table IX-8 indicate varying degrees of overlap among the subtests.

Tables IX-9 and IX-10 present conversions from raw scores to percentiles and standard scores.

Table IX-1

ELECTRICAL INSTALLATION AND MAINTENANCE

Test Specifications

CURRICULUM CONTENT AREA	K	U	A_k	A_u
I. DIRECT CURRENT				
A. Electron physics	14	5	5	1
B. Ohm's Law	6	2	5	1
1. Series, parallel	2		3	
2. Series, parallel	3	1		
C. Kirchoff's Law	3	4	1	2
1. Series, parallel	2	1		
2. Series, parallel		5		
D. Electrostatics and capacitance				
E. Magnetism	2			
1. Permanent magnets	3			
2. Electromagnets	1			
F. Meter movements	2	1		
G. Power sources	1			
II. ALTERNATING CURRENT				
A. Rotating vectors	2	2	3	3
B. Voltage and current generation	8	9	4	8
C. Reactance	2	3	3	2
1. Capacitance	9			
2. Inductance	4			
3. Phase angles	2			
D. Impedence	2	1		
1. Series				
a. L-R	3	1		
b. C-R				
c. L-C-R	3	1		
2. Parallel				
a. L-R				
b. C-R				
c. L-C-R	2	1		
E. Resonance				
1. Series	1			
2. Parallel	1			
F. Power factor	9	2		
G. Poly phase circuits	4	8		
H. Transformers	13	7	4	
III. MACHINES AND CONTROLS				
A. D.C. machines and controls	3			1
1. Generators	10	2	2	
2. Motors	12	7	1	2
B. A.C. machines and controls				
1. Alternator	7	2	1	
2. Motor	31	4	1	

	K	U	A_k	A_u
IV. WIRING	17	10	8	
A. Residential	11			
B. Commercial	8	3	2	
C. Industrial	30	11	7	
D. Blue print readings	3			
V. BASIC ELECTRONICS	3	3	1	2
A. Vacuum tubes	6			
1. Electron emission	4			
2. Diodes	4	1		
3. Triodes	3			
4. Multi-element	2			
5. Gas tubes				
B. Semi-conductors				
1. Solid-state physics	6			
2. Semi-conductor diodes	1		1	
3. Junction transistors	7		3	1
4. Field effect transistors	1	2		
C. Power supply	2	1		
1. Half-wave	1	1		
2. Full wave	1	2		
a. Bridge	1			
b. Conventional		1	1	
3. Voltage - multiplying	3	1		1
4. Filter networks	2			
D. Amplifiers				
1. Voltage	6		1	
2. Current	6	1	2	
3. Power	1	1	1	
E. Oscillators	1	1		
1. Sinusoidal			1	
2. Non-sinusoidal				
VI. INDUSTRIAL CONTROLS	2	8	9	2
A. Signal devices				
1. Thermocouple	3			
2. Photo electric cell	2		1	
3. Synchro and servo mechanism	13	2	1	
B. Switching circuits		2	1	
1. Time delay	5	2	2	1
2. Heat and light control	5		1	1
3. Logic		1	1	
VII. TROUBLESHOOTING (all fields)	50	30	18	10
VIII. CARE AND USE OF EQUIPMENT	2			
A. Tools	1	2		
B. Instruments	25	6		
IX. SAFETY				
A. Personnel	3	1		
1. Precautions	7			
2. First aid	2	1		
B. Equipment	4	1		

Table IX-2

ELECTRICAL INSTALLATION AND MAINTENANCE[1]
First Year

Description of Sample

State	No. of Inst.	No. of Students
Delaware	1	13
Georgia	1	11
New Jersey	3	39
North Carolina	6	47
South Carolina	7	94
	18	204

[1] In some states this curriculum is designated Industrial Electricity; in other states it is called Industrial Electronics.

Table IX-3

ELECTRICAL INSTALLATION AND MAINTENANCE
Experimental Tests

Description and Reliabilities

	Subtest	Time Limit (min)	No. of Items Form A	No. of Items Form B	Reliability Form A	Reliability Form B
I	Basic Electrical Theory	45	45	45	.72	.70
II	Machines and Controls	50	60	60	.80	.73
III	Construction Wiring	35	45	45	.73	.76
IV	Basic Electronic Thoery	25	30	30	.72	.85
V	Industrial Electronic Application	30	30	30	.78	.70
VI	Electrical Malfunctions	60	60	60	.76	.81
VII	Safety, Personal and Equipment	20	30	26	.61	.68
		265	300	296		

Table IX-4

INTERCORRELATIONS AND FACTOR LOADINGS FOR ELECTRICAL INSTALLATION AND MAINTENANCE

Experimental Test - Form A

	Intercorrelations															Factor Loadings				
	Subtests							Reference Tests												
	I	II	III	IV	V	VI	VII	MI	ShD	SM	SuD	FC	CC	WRV	Inf	1	2	3	4	h^2
I	--	54	24	26	41	43	40	29	18	23	26	26	10	16	16	59	05	-27	-39	58
II		--	62	40	45	54	43	38	19	15	05	14	-01	09	02	71	-10	-46	-13	74
III			--	38	34	32	27	32	15	22	-02	04	08	10	-14	45	-11	-67	08	66
IV				--	56	34	44	17	28	18	29	-14	-02	17	04	58	30	-22	35	60
V					--	60	50	16	27	12	30	02	-07	24	15	76	26	-04	11	66
VI						--	48	36	15	08	27	-01	-20	-07	18	84	01	05	-08	71
VII							--	32	16	23	34	09	-12	22	17	71	23	-06	-01	55
MI								--	30	16	33	10	13	41	17	31	36	-40	-11	40
ShD									--	08	37	14	23	49	39	12	72	-20	-01	57
SM										--	16	-02	23	15	-00	06	14	-59	04	37
SuD											--	34	19	31	47	29	62	08	-34	59
FC												--	33	09	44	03	13	-03	-88	79
CC													--	18	17	-33	25	-55	-42	65
WRV														--	47	00	80	-22	06	69
Inf															--	10	66	24	-47	72
														% Var.		47.4	24.6	14.6	13.4	
														Cum. %		47.4	72.0	86.6	100.0	

n = 100
Decimals omitted

Table IX-5

INTERCORRELATIONS AND FACTOR LOADINGS FOR ELECTRICAL INSTALLATIONS AND MAINTENANCE

Experimental Test - Form B

	Intercorrelations															Factor Loadings					
	Subtest							Reference Tests													
	I	II	III	IV	V	VI	VII	MI	ShD	SM	SuD	FC	CC	WRV	Inf	1	2	3	4	5	h^2
I	--	54	27	33	09	45	36	31	28	02	28	-19	05	12	06	64	20	06	05	34	57
II		--	35	23	12	48	29	38	32	06	-01	05	-11	03	-10	81	-07	03	-14	15	70
III			--	20	13	32	15	21	21	-05	03	-18	-18	04	-07	64	-04	-10	08	08	43
IV				--	31	57	52	17	32	-08	13	-16	-07	07	20	17	10	-12	15	80	72
V					--	25	08	04	06	-15	-03	-14	-11	-27	-02	11	03	-58	27	30	52
VI						--	49	28	35	06	06	-24	-27	12	01	52	-08	06	15	66	74
VII							--	22	36	04	21	17	-22	05	13	22	-13	10	-33	71	69
MI								--	32	00	42	14	49	18	21	50	62	-04	-19	09	68
ShD									--	00	43	24	-05	04	30	25	11	-05	-53	50	61
SM										--	-08	-03	00	32	10	-06	-06	77	12	14	63
SuD											--	46	38	37	36	06	60	04	-55	21	71
FC												--	22	07	08	-12	11	02	-88	-12	82
CC													--	47	39	-08	90	12	-02	22	88
WRV														--	00	15	44	70	01	-01	71
Inf															--	-35	56	-03	-09	45	65
															% Var	36.0	25.4	14.7	12.2	11.5	
															Cum. %	36.0	61.4	76.1	88.3	100.0	

n = 102
Decimals omitted

Table IX-6

ELECTRICAL INSTALLATION AND MAINTENANCE[1]
Second Year

Description of Sample

State	No. of Inst.	No. of Students
Delaware	1	12
Georgia	3	18
New Jersey	2	29
North Carolina	5	47
Pennsylvania	2	32
South Carolina	9	74
	22	212

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[1] In some states this curriculum is designated Industrial Electricity or Industrial Electronics.

Table IX-7

ELECTRICAL INSTALLATION AND MAINTENANCE

Psychometric Characteristics
Final Test

	Subtest	No. of Items	Time Limit	Reliability K-R (14)	Skewness	Kurtosis
I	Basic Electronic Theory	30	30 min	79	44	-32
II	Machines and Controls	45	50 min	87	65	-25
III	Construction Wiring	30	40 min	80	68	10
IV	Basic Electronic Theory	30	25 min	85	-14	-66
V	Industrial Electricity Applications	30	30 min	71	25	-22
VI	Diagnosis of Electrical Malfunctions	45	45 min	75	27	72
VII	Safety - Personal and Equipment	25	20 min	70	-40	21
	Total test			94	55	-94

Table IX-8

ELECTRICAL INSTALLATION AND MAINTENANCE

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V	VI	VII	TOTAL*
I	--	69	48	54	41	55	50	78
II		--	53	48	34	56	48	77
III			--	48	33	51	32	69
IV				--	70	66	54	83
V					--	60	38	69
VI						--	60	85
VII							--	70
Total								--

*Part-whole correlations
Decimals omitted

Table IX-9

RAW SCORE CONVERSIONS

ELECTRICAL INSTALLATION AND MAINTENANCE SUBTEST

	1		2		3		4		5		6		7	
Raw Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
39											99	800		
38											99	800		
37											99	800		
36			99	770							99	785		
35			99	755							98	768		
34			99	741							98	752		
33			98	726							98	736		
32			96	711							97	719		
31			95	696							96	703		
30			93	681			99	732			96	687		
29			92	666			99	716			95	670		
28	99	795	90	651			99	700			93	654		
27	99	775	87	637	99	778	98	684			93	638		
26	99	754	86	622	99	757	97	668			88	621		
25	98	733	85	607	98	737	96	652			87	605	99	790
24	97	713	80	592	97	716	93	635			84	589	99	765
23	95	692	80	577	94	696	89	619			80	572	99	741
22	94	672	77	562	92	676	83	603	99	781	78	556	99	716
21	93	651	72	547	92	655	79	587	98	758	73	540	98	691
20	92	631	68	533	90	635	74	571	98	735	62	523	98	667
19	88	610	63	518	87	615	70	555	98	712	56	507	97	642
18	83	590	60	503	83	594	63	539	97	689	52	491	90	617
17	77	569	58	488	79	574	60	523	95	666	46	474	86	593
16	72	549	53	473	77	554	54	507	93	643	40	458	80	568
15	65	528	46	458	71	533	48	490	89	620	30	442	67	543
14	57	508	37	443	68	513	44	474	86	597	23	425	56	519
13	51	487	28	429	60	492	37	458	79	574	19	409	48	494
12	45	467	21	414	49	472	33	442	74	551	15	392	40	469
11	36	446	15	399	40	452	26	426	66	529	10	376	30	444
10	31	425	10	384	31	431	20	410	56	506	6	360	23	420
9	23	405	5	369	19	411	17	394	49	483	3	343	19	395
8	14	384	3	254	12	391	15	378	41	460	2	327	12	370
7	10	364	3	339	7	370	13	362	30	437	2	311	7	346
6	5	343	1	325	5	350	7	346	24	414	2	294	5	321
5	1	323	1	310	2	330	4	329	17	391	2	278	4	296
4			1	295	2	309	3	313	10	368	1	262	2	272
3							2	297	8	345	1	245	1	247
2							1	281	3	322	1	229	1	222
1							1	265	1	299	1	213	1	200

Table IX-10

RAW SCORE CONVERSIONS

ELECTRICAL INSTALLATION AND MAINTENANCE TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
201	99	800	149	93	664	97	50	483	45	1	301
200	99	800	148	93	660	96	49	479	44	1	298
199	99	800	147	92	657	95	47	476	43	1	294
198	99	800	146	91	654	94	45	472	42	1	291
197	99	800	145	91	650	93	43	469	41	1	287
196	99	800	144	91	647	92	41	465	40	1	284
195	99	800	143	91	643	91	39	462	39	1	280
194	99	800	142	91	640	90	38	458	38	1	277
193	99	800	141	91	636	89	36	455	37	1	273
192	99	800	140	90	633	88	35	451	36	1	270
191	99	800	139	88	629	87	34	448	35	1	266
190	99	800	138	88	626	86	32	444	34	1	263
189	99	800	137	88	622	85	31	441	33	1	259
188	99	800	136	88	619	84	30	437	32	1	256
187	99	797	135	87	615	83	30	434	31	1	252
186	99	793	134	87	612	82	28	430	30	1	249
185	98	790	133	86	608	81	26	427	29	1	245
184	98	786	132	85	605	80	26	423	28	1	242
183	98	783	131	85	601	79	24	420	27	1	238
182	98	779	130	84	598	78	22	416	26	1	235
181	98	776	129	83	594	77	20	413			
180	98	772	128	82	591	76	17	409			
179	98	769	127	82	587	75	15	406			
178	98	765	126	81	584	74	15	402			
177	98	762	125	80	580	73	14	399			
176	98	758	124	79	577	72	13	395			
175	98	755	123	78	573	71	11	392			
174	98	751	122	78	570	70	11	388			
173	98	748	121	78	566	69	10	385			
172	98	744	120	76	563	68	9	381			
171	98	741	119	76	559	67	9	378			
170	98	737	118	74	556	66	7	374			
169	98	734	117	72	552	65	7	371			
168	98	730	116	71	549	64	7	367			
167	98	727	115	68	545	63	5	364			
166	98	723	114	67	542	62	3	361			
165	98	720	113	67	538	61	3	357			
164	98	716	112	66	535	60	2	354			
163	97	713	111	66	531	59	2	350			
162	97	709	110	65	528	58	2	347			
161	96	706	109	63	524	57	2	343			
160	96	702	108	60	521	56	2	340			
159	95	699	107	59	517	55	2	336			
158	95	695	106	58	514	54	2	333			
157	94	692	105	55	510	53	2	329			
156	94	688	104	54	507	52	1	326			
155	94	685	103	53	504	51	1	322			
154	94	681	102	53	500	50	1	319			
153	94	678	101	52	497	49	1	315			
152	93	674	100	52	493	48	1	312			
151	93	671	99	52	490	47	1	308			
150	93	667	98	51	486	46	1	305			

CHAPTER X

RADIO AND TELEVISION SERVICING

A. EXPERIMENTAL TESTS

Tables X-1 through X-3 present test specifications, a description of the sample, and detailed psychometric characteristics for the experimental Radio and Television Servicing tests. From Table X-3 it can be seen that the reliabilities of the experimental subtests ranged from .22 to .90. Table X-4 presents the intercorrelations and factor analysis results for form A of the experimental test. It can be seen that all of the subtests except X load on factor 1. This factor, which accounts for 43 per cent of the common variance, appears to be the one underlying the general ability needed for success in the Radio and Television Servicing curriculum. None of the reference tests load on this factor. Subtest III, Vacuum Tubes, has a moderate loading on factor 4 but the fact that this is a bipolar factor suggests that it is not a meaningful dimension of performance.

Table X-5 presents the intercorrelations and factor analysis results for form B of the experimental test. All the subtests, including subtest X, load on factor 1, which accounts for 49 per cent of the common variance. Factor 2 seems to be a bipolar factor with the performance tests, TV-Dynamic and TV-Static, representing manipulation abilities and the Cube Comparison, Subtraction-Multiplication, and Wide Range Vocabulary reference tests representing general and abstract reasoning. The two analyses agree fairly closely, although the reference tests for form A show some moderate loadings on a variety of factors whereas a few tests load on factor 2 for form B.

B. FINAL TEST

The description of the sample for Radio and Television Servicing is presented in Table X-6 and psychometric characteristics for this test are presented in Table X-7. It can be seen from this table that the subtests have reliabilities ranging from .78 to .86, with a total test reliability of .96. It can also be seen from this table that the skewness for the subtests is not large except for Subtest II. Kurtosis, although negative for most of the subtests, is not large except for Subtest II which is highly positive, i.e., leptokurtic. Interpreted thusly, Subtest II had the students' results clustering very significantly about the mean, i.e., there was not a wide range of scores. From the intercorrelations in Table X-8 it can be seen that the subtests have moderate to high intercorrelations. The homogeneous intercorrelations would indicate that the subtests all measure about the same degree of common variance, as was found in the factor analyses of the experimental tests

Norms for converting raw scores to percentiles, and standard scores are presented in X-9 for subtests and Table X-10 for total test scores.

Table X-1

RADIO-TELEVISION SERVICING

Test Specifications

CURRICULUM CONTENT AREA	K	U	A_k	A_u
I. FUNDAMENTALS OF DIRECT CURRENT				
A. Series	9	4	5	2
B. Parallel	8	3	4	
C. Combination (series-parallel)	5	2	3	
II. FUNDAMENTALS OF ALTERNATING CURRENT				
A. Series	10	34	14	
B. Parellel	12	22	10	
C. Combination (series-parallel)	10	12	4	
D. Resonance	9	17	3	
III. VACUUM TUBES				
A. Diode	13	3	1	
B. Triode	15	15	3	3
C. Tetrade		3	1	
D. Pentode	9	2		
E. Special	5	5	1	
IV. POWER SUPPLY				
A. Half-wave	4	2	2	
B. Full-wave	2	4	3	1
C. Bridge	2		2	
D. Doublers		2		
E. Filters	5	1	2	
F. Special	1	1	1	
V. AMPLIFIERS				
A. Audio	30	16	13	
B. Radio-frequency (R.F.)	14	6	2	1
C. Video	16	5	4	1
D. Special	7	2	2	
VI. SPECIAL CIRCUITS				
A. Oscillator	20	5	2	
B. Detector	8	3		
C. Conventor	1	1		
D. Special	3	6	5	
VII. SEMI-CONDUCTORS				
A. Diode	24	6	1	
B. Transistor	50	7	1	1
C. Other or special	9	1		

	K	U	A_k	A_u
VIII. RADIO RECEIVER				
A. T.R.F. (Tuned radio frequency)	11	3	5	
B. Super hetradyne				
1. Home				
a. A.M.	3	2	2	
b. F.M.	3	1	1	
2. Auto				
a. A.M.	3			
b. F.M.	3			
C. Stereo Multiplex	4			
D. Multiband				
E. Special	2		1	
IX. TELEVISION				
A. Black and white	33	27	13	
B. Color	34	20	7	5
X. TEST EQUIPMENT AND TOOLS				
A. Types	6	2	2	
B. Use	6	5		
C. Maintenance	1			
D. Safety Practices	2	1		

Table X-2

RADIO AND TELEVISION SERVICING[1]
First Year

Description of Sample

State	No. of Inst.	No. of Stu.
Delaware	1	10
Georgia	1	13
North Carolina	8	73
South Carolina	2	13
	12	109

[1] This curriculum is sometimes designated Industrial Electronics or Electronics Servicing.

Table X-3

RADIO AND TELEVISION SERVICING
Experimental Tests

Description and Reliabilities

	Subtest	Time Limit (Min)	No. of Items Form A	No. of Items Form B	Reliability Form A	Reliability Form B
I	Fundamentals of Direct Current	20	24	23	.71	.71
II	Fundamentals of Alternating Current	45	40	40	.78	.50
III	Vacuum Tubes	20	22	22	.62	.72
IV	Power Supply	15	17	17	.47	.54
V	Amplifiers	20	21	20	.55	.74
VI	Special Circuits	20	20	23	.77	.85
VII	Semi-Conductors	20	23	23	.73	.64
VIII	Radio Receiver	15	16	15	.22	.52
IX	Television	60	64	63	.90	.89
X	Test Equipment and Tools	5	9	9	.59	.53
		240	256	255		

Table X-4

INTERCORRELATIONS AND FACTOR LOADINGS FOR RADIO AND TELEVISION REPAIR

Experimental Test - Form A

	Intercorrelations																								
	Subtests										Reference Tests								(1)		Factor Loadings				
	I	II	III	IV	V	VI	VII	VIII	IX	X	MI	ShD	SM	SuD	FC	CC	WRV	Inf	TV-D	TV-S	1	2	3	4	h^2
I	--	49	38	52	47	55	49	52	46	14	46	37	26	19	08	22	34	23	35	56	62	22	21	19	51
II		--	36	51	47	53	55	37	48	17	19	33	25	14	02	11	18	22	04	16	65	25	03	-07	49
III			--	50	50	46	37	57	64	30	38	20	15	15	-13	26	31	36	48	52	49	23	13	54	60
IV				--	57	60	51	47	57	22	37	34	-08	24	-02	03	14	02	25	44	75	06	-07	19	61
V					--	58	61	58	57	07	24	20	06	29	12	-02	06	-02	23	47	79	-05	03	07	63
VI						--	63	60	56	-18	37	41	23	31	01	20	24	31	58	55	72	15	31	16	66
VII							--	57	54	14	33	37	28	33	02	03	21	22	51	27	70	15	27	04	59
VIII								--	68	13	29	14	18	13	03	17	41	25	43	41	65	20	18	25	56
IX									--	29	44	-04	11	25	00	15	32	29	60	49	67	07	19	40	65
X										--	04	-11	07	-05	-02	-01	15	13	10	-06	11	12	-04	15	05
MI											--	15	09	32	-38	07	32	-20	45	62	33	-07	17	63	54
ShD												--	51	-25	01	20	55	60	00	-02	23	74	17	-13	64
SM													--	25	-16	24	21	31	84	-12	-03	32	86	00	84
SuD														--	40	24	-15	-14	14	47	40	-41	33	-05	44
FC															--	23	11	04	26	-24	17	-11	21	-55	39
CC																--	-06	26	26	-04	12	08	35	-10	16
WRV																	--	68	21	-09	16	73	11	14	59
Inf																		--	04	45	13	76	15	09	62
TV-D																			--	62	27	-06	86	38	96
TV-S																				--	48	-14	16	62	66
																		% Var.			43.3	20.1	19.4	17.2	
																		Cum. %			43.3	63.4	82.8	100.0	

n - 53
Decimals omitted
(1) Performance Tests

Table X-5

INTERCORRELATIONS AND FACTOR LOADINGS FOR RADIO AND TELEVISION REPAIR

Experimental Test - Form B

	Intercorrelations																								
	Subtests										Reference Tests								(1)		Factor Loadings				
	I	II	III	IV	V	VI	VII	VIII	IX	X	MI	ShD	SM	SuD	FC	CC	WRV	Inf	TV-D	TV-S	1	2	3	4	h^2
I	--	47	65	55	58	59	64	48	60	49	42	74	15	21	21	15	41	52	13	24	71	07	38	15	68
II		--	56	63	50	60	66	38	49	57	36	44	18	11	-29	09	48	29	12	17	70	06	20	-24	59
III			--	55	62	60	70	49	59	53	44	42	08	07	16	25	43	25	10	42	75	02	17	07	60
IV				--	52	58	60	44	54	51	54	33	06	33	-01	04	15	17	28	45	75	-15	-03	-01	58
V					--	71	69	54	70	63	47	44	06	09	05	22	23	38	27	18	77	00	11	15	64
VI						--	71	52	61	53	53	63	00	27	-16	-14	28	22	18	19	79	-10	18	-16	69
VII							--	56	56	64	49	65	-02	03	-09	02	44	32	28	38	81	-12	30	-06	76
VIII								--	60	63	46	36	10	43	08	36	49	20	-04	39	75	14	-09	05	59
IX									--	51	25	34	23	26	10	37	42	30	30	36	77	08	-01	22	64
X										--	52	29	03	20	-03	25	27	26	25	13	75	04	-05	09	57
MI											--	46	-02	30	-06	13	30	31	15	08	61	02	08	00	38
ShD												--	04	-02	24	06	47	67	00	25	52	04	68	04	74
SM													--	03	06	50	43	28	-56	-68	07	81	13	-09	68
SuD														--	-02	34	01	-20	-12	12	36	13	-45	-01	35
FC															--	15	33	30	56	-46	-06	18	22	77	68
CC																--	32	10	-10	-69	24	71	-27	32	74
WRV																	--	48	-38	-20	40	51	41	01	59
Inf																		--	35	22	30	07	67	33	66
TV-D																			--	58	20	-60	29	63	80
TV-S																				--	38	-82	06	-11	84
																		% Var			54.5	20.3	14.0	11.2	
																		Cum %			54.5	74.5	88.8	100.0	

n = 56

Decimals omitted

(1) Performance Tests

Table X-6

RADIO AND TELEVISION SERVICING
Second Year

Description of Sample

State	No. of Inst.	No. of Stu.
Delaware	1	14
Georgia	6	38
North Carolina	10	84
South Carolina	2	16
	19	152

Table X-7
RADIO AND TELEVISION SERVICING

Psychometric Characteristics
Final Test

	Subtest	No. of Items	Time Limit	Reliability K-R (14)	Skewness	Kurtosis
I	Fundamentals of Direct Current	35	25 min	81	14	-58
II	Fundamentals of Alternating Current	45	40 min	81	1.14	1.65
III	Fundamentals of Vacuum Tubes	30	25 min	78	52	-43
IV	Semi-Conductors	35	30 min	79	38	-11
V	Circuits	50	40 min	84	42	-39
VI	Radio	35	30 min	82	35	-37
VII	Television	70	50 min	86	-21	-48
	Total test			96	48	-56

Table X-8
RADIO AND TELEVISION SERVICING

Subtest Intercorrelations
Final Test

Subtest	I	II	III	IV	V	VI	VII	TOTAL*
I	--	55	58	56	62	62	57	76
II		--	60	62	63	57	58	78
III			--	70	77	74	63	85
IV				--	66	68	55	80
V					--	80	72	90
VI						--	66	87
VII							--	84
Total								--

*Part-whole correlations
Decimals omitted

Table X-9

RAW SCORE CONVERSIONS

RADIO AND TELEVISION SERVICING SUBTESTS

	1		2		3		4		5		6		7	
Raw Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score	%ile	Std. Score
46													99	704
45													99	693
44													98	683
43													97	673
42													96	662
41									99	742			93	652
40									99	730			91	641
39									99	718			90	631
38									96	706			87	621
37									96	694			86	610
36			99	800					95	682			84	600
35			99	800					93	670			81	590
34			99	800					91	658			81	579
33			98	800					89	646	99	785	77	569
32			97	796					87	634	99	769	74	559
31			97	780					86	622	99	753	72	548
30	99	753	97	765					83	610	98	738	66	538
29	99	736	97	749					83	598	98	722	59	527
28	99	719	96	734			99	760	81	586	98	706	53	517
27	98	702	95	718			99	743	79	574	97	691	46	507
26	97	685	95	703			98	726	76	562	96	675	44	496
25	96	668	95	687	99	760	97	709	72	550	94	660	41	486
24	93	651	93	672	99	740	96	692	69	538	91	644	38	476
23	89	634	91	656	98	721	93	675	66	526	90	628	36	465
22	87	617	89	641	98	702	92	658	62	514	85	613	34	455
21	83	600	88	625	97	682	90	641	57	503	81	597	32	445
20	81	583	87	610	92	663	88	624	54	491	79	581	30	434
19	77	566	86	594	89	644	85	606	50	479	74	566	28	424
18	70	550	84	579	84	624	81	589	44	467	72	550	22	413
17	63	533	81	563	82	605	77	572	39	455	66	535	21	403
16	58	516	79	548	79	586	73	555	34	443	62	519	15	393
15	54	499	77	532	77	566	71	538	28	431	58	503	14	382
14	48	482	69	517	74	547	69	521	23	419	53	488	12	372
13	42	465	62	501	68	528	59	504	21	407	48	472	8	362
12	34	448	56	486	65	508	56	487	16	395	38	456	7	351
11	31	431	46	470	58	489	47	470	9	383	34	441	6	341
10	23	414	38	455	50	470	38	453	7	371	29	425	6	331
9	17	397	29	439	38	450	30	436	6	359	21	410	4	320
8	13	380	23	424	31	431	22	419	3	347	17	394	3	310
7	9	363	18	408	22	412	13	402	2	335	11	378	2	299
6	7	347	11	393	13	392	11	385	1	323	6	363	1	289
5	4	330	8	377	9	373	9	368	1	311	5	347	1	279
4	4	313	2	362	4	354	4	351	1	299	2	331	1	268
3	1	296	1	346	1	334	3	334	1	287	1	316	1	258
2			1	331	1	315	3	317	1	275	1	300	1	248
1			1	315	1	296	2	300	1	263	1	285	1	237

Table X-10

RAW SCORE CONVERSIONS

RADIO AND TELEVISION SERVICING TOTAL TEST

Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score	Raw Score	%ile	Std. Score
212	99	745	159	83	612	106	49	479	53	1	346
211	99	743	158	82	610	105	47	477	52	1	344
210	99	740	157	82	607	104	47	474	51	1	341
209	99	738	156	82	605	103	45	472	50	1	339
208	98	735	155	81	602	102	44	469	49	1	336
207	98	733	154	81	600	101	42	467	48	1	334
206	98	730	153	79	597	100	41	464	47	1	331
205	97	728	152	79	595	99	41	462	46	1	329
204	97	725	151	78	592	98	41	459	45	1	326
203	97	723	150	78	590	97	40	457	44	1	324
202	97	720	149	78	587	96	39	454	43	1	321
201	97	718	148	77	585	95	39	452	42	1	319
200	97	715	147	77	582	94	36	449	41	1	316
199	97	713	146	77	580	93	34	447	40	1	314
198	97	710	145	76	577	92	33	444	39	1	311
197	96	708	144	75	575	91	32	442	38	1	309
196	96	705	143	75	572	90	31	439	37	1	306
195	96	703	142	75	570	89	30	437	36	1	304
194	96	700	141	75	567	88	29	434	35	1	301
193	96	698	140	74	565	87	28	432	34	1	299
192	96	695	139	74	562	86	27	429	33	1	296
191	95	693	138	73	560	85	25	427	32	1	294
190	95	690	137	72	557	84	24	424	31	1	291
189	95	688	136	72	555	83	22	422	30	1	289
188	95	685	135	72	552	82	21	419	29	1	286
187	95	683	134	72	550	81	20	417	28	1	284
186	94	680	133	71	547	80	19	414	27	1	281
185	94	678	132	71	545	79	19	412	26	1	279
184	94	675	131	70	542	78	18	409	25	1	276
183	94	673	130	69	540	77	17	407	24	1	274
182	93	670	129	68	537	76	15	404	23	1	271
181	93	668	128	68	535	75	15	402	22	1	269
180	93	665	127	66	532	74	13	399	21	1	266
179	93	662	126	66	530	73	12	397	20	1	264
178	93	660	125	66	527	72	11	394	19	1	261
177	92	657	124	66	525	71	11	392	18	1	259
176	92	655	123	65	522	70	10	389	17	1	256
175	89	652	122	65	519	69	8	387	16	1	254
174	89	650	121	64	517	68	7	384	15	1	251
173	88	647	120	64	514	67	7	382	14	1	249
172	87	645	119	63	512	66	6	379	13	1	246
171	87	642	118	63	509	65	6	376	12	1	244
170	86	640	117	62	507	64	5	374	11	1	241
169	85	637	116	62	504	63	5	371	10	1	239
168	85	634	115	62	502	62	3	369	9	1	236
167	84	632	114	60	499	61	3	366	8	1	233
166	84	630	113	59	497	60	3	364	7	1	231
165	83	627	112	58	494	59	2	361	6	1	228
164	83	625	111	57	492	58	2	359	5	1	226
163	83	622	110	56	489	57	2	356	4	1	223
162	83	620	109	54	487	56	2	354	3	1	221
161	83	617	108	52	484	55	1	351			
160	83	615	107	50	482	54	1	349			

CHAPTER XI

DIAGNOSTIC PERFORMANCE MEASURES

The following three summaries are from thesis research efforts conducted by doctoral graduate students while at the University of Illinois. The studies are diagnostic ability measures for three of the trade areas investigated in this Project: Machinist, Radio-Television Servicing, and Automotive Mechanics. The studies were conducted on a sample of those students who took the paper-and-pencil test in each area.

AUDITORY DIAGNOSTIC PERFORMANCE AS A CRITERION MEASURE FOR MACHINISTS - D. W. Becker[1]

The problem of this study was to determine if auditory diagnostic performance exists as a separate dimension of machining performance.

In the initial phase of the study an instrument, Auditory Achievement Test for Machinist (AATM), was developed. The AATM was constructed by setting up machining operations in which typical malfunctions were "built in." The sounds produced by the malfunctioning processes were then recorded with high fidelity tape recording equipment. Each sound was prefaced with a brief description of the machining operation involved and four possible causes of the sound were presented. After hearing the sound, through binaural head phones, the respondent selected from the several alternatives the one which supposedly identified the malfunction and marked it on the printed answer sheet. The entire test of sixty-four questions, including instructions, was placed on the tape. The total running time for AATM was one hour and twenty minutes.

Three different samples were used in the study. The first was chosen from a population having no appreciable amount of machining experience. The second sample was composed of students who had just completed a one year post high school machinist training program and the third sample contained experienced machinists who were working in the trade.

The odd-even reliabilities on AATM of -.122 for nonmachinists, .261 for student machinists, .558 for experienced machinists, and .513 for the total sample tested were not considered high enough to make fine distinctions of auditory diagnostic performance. It was encouraging, however, that the highest reliability reported was for the machinist group. The belief that reliabilities could be improved through AATM revision was supported.

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[1] Now at Wichita (Kansas) State University

The construct validity, that auditory diagnostic performance increases with auditory diagnostic experience, was tested and supported. Comparisons of achievement between the groups tested by one-way analysis of variance and by separate t tests between the groups were made. The F value was found to be significant beyond the .0001 level and each of the three one tailed t tests produced a t value which was significant beyond the .0005 level.

A correlation coefficient of .189 ($p < .025$) was considered too low to support the peer nomination technique as a concurrent measure of auditory diagnostic achievement.

The value of auditory aptitude in predicting auditory diagnostic performance was supported. A multiple correlation between AATM and the auditory aptitude battery was .428 ($p < .0005$) and a revised AATM with an increased range and reliability should significantly increase the predictive potential of the Auditory Aptitude Test Battery.

The independence of AATM and the paper-and-pencil Achievement Test for Machinist was only partially supported. A comparison of these two measures produced a correlation coefficient of .315 ($p < .005$).

ICONIC COMPARISON OF PHOTOGRAPHS AND THE LIVE TELEVISION SCREEN IN VISUAL DIAGNOSTIC ABILITY - Jarrel Hoffer[1]

This research centered around two major problems. The first was to develop an achievement test to measure the additional dimension of visual diagnostic ability. The second problem was to test the iconic equivalence of photographs with motion cues and live screen presentation of defective television reception for testing purposes. Related questions concerning reliability, validity, and the dimensions of visual diagnosis were also studied.

A panel of radio-television instructors and technicians was utilized to write questions and judge the appropriateness of items for the test. The malfunctions were wired into a Tele-Lab (R.W.S. Industries, Cleveland, Ohio; Courtesy: Mr. Alvin Stumpf) trainer so that they could be switched in, at will, for presentation during the test. Fifty multiple choice questions representing twenty-seven malfunctions were used. The malfunctions affected the audio only, the video only, or both the audio and the video. This test is the Visual Diagnostic Test for Television Servicing Dynamic or dynamic test. The live screen used in the dynamic test served as the photographic model for the

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[1] Now at Western Illinois University

Visual Diagnostic Test for Television Servicing Static or static test. Verbal motion cues were presented beside each photograph on the static test. The static and dynamic tests were identical except for the method of presenting the visual information in the malfunctions. To equalize the two tests, a statement of the audio condition was presented within each question.

The static and dynamic tests were administered to eighty-nine students who were completing one year programs in radio-television servicing. For economic and logistic reasons, the students were administered both the static and dynamic tests in one sitting. They were divided into two groups so that approximately one-half of them took the static test first and one-half took the dynamic test first. The students also took, at a different sitting, a three hundred item multiple choice test for knowledge of basic electronics, the RTV test.

The static and dynamic tests were also administered to a sample of twenty-four technicians who were employed full-time in radio-television servicing.

Hypotheses 1 and 2 stated that the static and dynamic tests are reliable. The Kuder-Richardson formula 14 yielded a validity index of .728 and .698, respectively, for the static and dynamic tests. This is a moderately high reliability; however, since the equipment and testing procedures have not been perfected this reliability was considered adequate and hypotheses 1 and 2 were accepted.

Hypotheses 3 and 4 stated that the static and dynamic tests are valid measures. Students and technicicans were compared using analysis of variance. An F ration of 29.31 was obtained which is significant beyond the .01 level; therefore, hypotheses 3 and 4 were accepted.

Hypothesis 5 stated that photographs with verbal motion cues are equivalent to live screen presentation of defective television reception for testing purposes. A product-moment correlation of .81 was obtained between the static and dynamic tests. A correlation of .71 is the highest correlation that is theoretically possible between the tests, estimated from the reliabilities of the tests, and is less than the obtained correlation. When corrected for attenuation, the correlation is slightly greater than unity. The assumptions underlying the reliability formula were violated, giving an underestimate of the reliabilities. This could explain why the obtained correlation was higher than theoretically possible and also why the correlation corrected for attenuation is greater than unity. A high correlation was considered to be strong evidence that the tests are equivalent. The static and dynamic tests were also compared by analysis of variance. F ratios of 7.88 for students and 10.02 for students and technicians were obtained and are significant beyond the .01 level. Only partial support was given to this hypothesis from the statistical tests; therefore, hypothesis 5 was rejected. The requirements of equivalence are quite rigorous and are frequently not met by well recognized tests. The static and dynamic tests do meet the most important requirements of equivalence; therefore from a practical standpoint, the tests may be considered equivalent.

Hypotheses 6 and 7 stated that the static and dynamic tests are independent of trade-related cognitive knowledge as measured by a paper and pencil test of knowledge of basic electronics. The static test correlated .58 and the dynamic test .60 with the RTV test, a paper and pencil test of knowledge of basic electronics. These correlations indicate a reasonably strong relationship; therefore, the static and dynamic tests are not independent and hypotheses 6 and 7 were rejected.

Hypotheses 8 and 9 stated that the static tests each measure a single dimension. The tests were factor analyzed using a principal axis factor analysis with varimax rotation. The results of the analysis indicate that, on both the static and dynamic tests, factors two, three, and four are each about one-half as strong as factor one. This indicates a more complex relationship rather than a single dimension; therefore, hypotheses 8 and 9 were rejected.

Hypothesis 10 stated that the static and dynamic tests are measures of the same dimension. This relationship was studied with factor analysis. The results indicate that the items of the two tests do load on the factors in a similar manner. The factors of the two tests were also similar with regard to the kinds of problems that loaded on each of the factors. The static test correlated .58 and the dynamic test correlated .60 with the RTV test. The results of the factor analysis and the correlations were taken as evidence that the static and dynamic tests are measures of the same dimension; therefore, hypothesis 10 was accepted.

AUDITORY AUTOMOTIVE MECHANICS DIAGNOSTIC ACHIEVEMENT TEST (AAMDAT) - R. A. Swanson[1]

It was the purpose of this study to develop and validate a test to measure the ability to diagnose malfunctions in automobiles through the auditory sense. The goal was to develop a test having from forty to sixty auditive malfunctions that would take approximately one hour to administer. The completed test, one hour in length, had a total of forty-five items. These malfunctions were built into automobiles; e.g., installing a bad connecting rod bearing into an otherwise perfectly running engine. Using a high quality binaural recording-reproducing system the malfunctioning automobiles were recorded. The malfunctioning sounds that received the highest combined ranking from a staff of automobile mechanics instructors and automobile mechanics, ranking independently, were selected for inclusion in the test.

The Auditory Aptitude Test Battery (Fleishman and Friedman, 1957) was shortened for use in this study. This was done to keep the total auditory achievement and aptitude testing time within a two and one half hour time limit. The inclusion of this test battery was to determine how well auditory aptitude predicts auditory diagnostic ability in auto mechanics.

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[1] Now at Bowling Green (Ohio) State University

Auditory diagnostic achievement as measured by the AAMDAT was found to have a reliability of .71 for the total group (N = 269). The reliability for the no experience group (N = 67) was .335, .433 for the first year auto mechanic students (N = 91), .436 for the graduating second year auto mechanic students (N = 44). In its present form the AAMDAT cannot be considered a sufficiently reliable test to make fine discriminations in auditory diagnostic ability between individuals within any one of the groups in this study. The belief that a careful revision of the AAMDAT would result in an instrument with this discriminating ability was supported in the analysis and discussion of the data.

The construct validity of the AAMDAT was tested and supported through the theoretical construct that auditory diagnostic ability increases with experience. The auto mechanics achieved significantly higher ($P<.0005$) than the graduating auto mechanics students, whose achievement was in turn significantly higher ($P<.01$) than the first year auto mechanics students, whose achievement was significiantly higher ($P<.0005$) than the no experience group. An analysis of variance computation of the same data produced an F value significant beyond the .0001 level.

The concurrent validity of the AAMDAT, which was evaluated by correlating AAMDAT achievement to peer nominations on the same dimension, was partially supported. These independent measures of auditory diagnostic ability correlated .256 for the first year auto mechanics students, .327 for the graduating auto mechanics students, and .161 for the auto mechanics. These low correlations may be partially explained by the limited range and reliability on the AAMDAT, as well as the questionable validity of the peer nomination technique as an intermediate criterion.

A principle axes factor analysis on the AAMDAT items produced several groups of items having high intercorrelations. These independent dimensions of auditory diagnostic ability were reviewed in order that they be identified in psychological terms. Factor one was identified as a basic experience factor, factor two a subtle tonal memory factor, and factor three a rhythm factor. The weaker remaining three factors were left unidentified.

The potential of the Auditory Aptitude Test Battery as a predictor of auditory diagnostic achievement was revealed in the multiple correlation of the nine predictor tests to the AAMDAT. A multiple correlation of .41 ($P<.0001$) between these measures was achieved for the graduating auto mechanics students. A revised AAMDAT with an increased range and reliability should significantly increase the predictive potential of the Auditory Aptitude Battery.

The independence of AAMDAT and paper and pencil auto mechanics test achievement was supported. The graduating auto mechanics students resultes on these two measures had a .249 correlation.

APPENDIX

A. DESCRIPTION OF PERFORMANCE TESTS

The following is a brief description of the performance tests used, primarily in the first year's testing program, in addition to those discussed in Chapter XI.

Plug and Ring Gauge Test (PR)

This test was used to measure the fine tactile kinesthetic sensitivity of students with respect to their ability to discriminate by feel between the different fits of plugs and rings. It was believed that through trade training in Automotive Mechanics; Air Conditioning, Heating and Refrigeration; Machinist; and Electrical Installation and Maintenance, students would be able to discriminate a skill in ranking the fits according to size in a manner superior to untrained students.

Three sets, each with five plugs and rings, were used as the testing equipment. These metal plugs were machined so that when a standard one-inch ring was placed on each a distinct fit was obtained. The task was to rank the five plugs according to size from largest to smallest. This was a rank-order test; the score being the difference between the correct rankings and the students' ranking.

Measurement Pod Test (MP)

This test was administered to students in Machine Shop and Auto Mechanics and measured the degree of skill with which precise measurements could be made. A tactile kinesthetic sensitivity factor was also present because of the importance of "touch" and "feel" in performing these tasks.

The measurement pod was composed of fifteen gauge blocks connected in such a manner as to provide for four measurements using feeler gauges and four measurements using one and two inch micrometers.

The student was required to list his answers to the fourth decimal place, which involved interpolation in some of the cases. A time limit of six minutes was imposed, and the score for the test was the absolute sum of the variances expressed as a whole number of ten thousandths of an inch.

Electircal Trouble-shooting Test for Automotive Mechanics (TS)

The object of this test was to measure the student's ability to locate and identify electrical malfunctions wherever they occur in the car's system.

A rectangular metal box, on which were mounted all the electrical components found in an automobile, was constructed so that by means of a switch panel, eighteen different electrical malfunctions could be introduced into the system. Circuits involving the ignition, head and tail lights, directional signals, parking lights and stop lights were used. A series of junction and fuse panels, externally mounted, provided the means by which the student could trouble-shoot the circuits at different points using a jump cable and probe.

The test was constructed so that the student responded to a written statement about a particular malfunction, i.e., statements were identical to those which might be voiced by a customer who describes what he thinks is wrong with his car. The student had to locate and identify the trouble and give his answer to the test administrator who noted it on the answer sheet.

The score was the number of items done correctly within the twenty minute time limit.

Dynamometer Test (Dyn)

Accuracy with the dynamometer was used as one measure of kinesthetic sensitivity as it has proven to be a reliable measure. It was administered to skilled students in the Automotive Mechanics; Air Conditioning, Heating and Refrigeration; Machinist; and Electrical Installation and Maintenance curricula. The results were compared with the unskilled students acting as a control group. Both skilled and unskilled groups were divided into two groups, one with knowledge of results, one without. While blindfolded, the subject was directed to exert pressure of 20 pounds by squeezing the dynamometer in his hand. The absolute variation over several trials was used as raw score.

Tactile-Kinesthetic Sensitivity Test (TK)

This was another approach to measure fine tactile-kinesthetic sensitivity through a newly developed piece of equipment. This test was administered to students in Automotive Mechanics; Air Conditioning, Heating and Refrigeration; Machinist; and Electrical Installation and Maintenance. There was a push and pull rod suspended in a magnetic field. By increasing or decreasing the electrical input, the pressure required to move the rod would vary. The task was to compare a designated standard weight with a different weight by comparing the amount of pressure required to pull the rod at various field intensities. The subject was required to tell whether the pressure was higher or lower than the standard pressure.

Automotive Diagnostic Scope Test (D-S)

This test was designed to measure the student's ability to diagnose ignition faults in an automobile engine using an analyzer scope. His ability to identify correctly the cause of malfunction by this method was considered an important facet of performance achievement in automotive mechanics. There were two forms of the test, static and dynamic. The static test used a booklet of pictures of a scope screen and a question and answer sheet. The dynamic portion of the test employed the actual scope. By using an engine simulator, patterns identical to those listed on the static test booklet were imposed upon the screen. Although the items on each test were identical, they were not offered in the same sequence nor were the multiple choice answers listed in the same order. In both parts of the test, each item was timed at thirty seconds. The score was the number of correct responses minus one third of the incorrect responses. After initial administration of the two forms, a comparison of reliabilities and the relationship between the two was examined.

Machine Indexing Test for Machinists (Ind)

This test was designed to measure the tactile-kinesthetic sensitivity which is developed through Machine Shop training and which is necessary to perform certain tasks upon prcision machine tools.

In the machine shop, the most up to date vertical or horizontal milling machine was used to demonstrate and measure the student's skills. Using only the cross feed screw, the subject was required to perform a series of ten movements, moving the table in and out according to instructions given verbally by the test administrator. An indicator mounted on the machine revealed to the test administrator the results of the subject's moves. The score was the total absolute variance of all ten moves.

Truing Test for Machinists (Tru)

This test measured the learned eye-hand-mind coordination of students. A plug of convenient diameter was placed in a four jaw chuck which was mounted in an engine lathe. Prior to the test, the plug was offset 1/16". The student was required to perform four tasks in a ten minute period. He had to true the plug to within ±.0005 as task #1, task #2 was to offset the plug by 1/16" ± .0005; tasks #3 and #4 were the reverse of tasks #1 and #2. These tasks required that the student return the equipment to its original setting. This rendered it ready for the next student.

This was a timed test. Each task was timed and noted on the score sheet provided. The score was the total time needed to accomplish the four tasks expressed as a whole number of quarter minutes. This score would inversely relate to the overall skill of the subject.

B. KIT OF REFERENCE TESTS FOR COGNITIVE FACTORS[1]

In various research over the last several years, many separate factors of aptitude and achievement have been identified. In 1951, Educational Testing Services (ETS) began a project to select those factors which could be agreed upon as measuring separate facets of aptitude or achievement and to develop instruments which would measure these factors. In 1958, the Office of Maval Research began supporting the effort. Using committees of the most respected researchers in the

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[1] Developed by Educational Testing Service, Princeton, New Jersey

United States, ETS led the activity which resulted in the selection of twenty-four factors which were considered to be independent facets of aptitude and the naming of more than seventy tests deemed suitable for measuring these factors. Each factor has at least three tests designed for different grade levels or using different approaches to measurement of the aptitude factor. The purpose of the Kit is best defined by the authors themselves. In their words:

> The purpose of the Kit is to provide research workers with a set of tests for defining each of these factors. It is intended that use of the Kit tests for this purpose will facilitate interpretation and the confident comparison of one factor study with another. In the past it has often been necessary to cross-identify the factors in two studies by means of psychological interpretation alone, sometimes without any tests common to the two studies. It is undesirable that this kind of subjective identification prevail. There are now in existence several techniques for objectively comparing a factor found in one analysis with that found in another. All methods of this kind require sets of tests that are common to the two studies. Use of the Kit tests should provide this common ground for the objective comparison of factors.

Some of the factors identified in the Kit have only been isolated in laboratory research while others of the factors have been readily identified in field research. The following pages describe those factors which this project staff and others with expert opinions felt to be contained in achievement in trade and technical education and were subsequently used in this testing program as a means of factor identification. The abbreviations used for the Reference Tests are shown in parentheses.

[x]Factor Fw:	Word Fluency The facility in producing isolated words that contain one or more structural, essentially phonetic, restrictions, without reference to the meaning of the words. Test: Word Endings (WE)
[x]Factor I:	Induction Associated abilities involved in the findings of general concepts that will fit sets of data, the forming and trying out of hypotheses. Test: Figure Classification (FC)
[x]Factor Mk:	Mechanical Knowledge The knowledge of mechanical principles, devices and tools, acquired through experience and training. Test: Mechanical Information (MI)
[x]Factor N.	Number Facility The ability to manipulate numbers in arithmetical operations rapidly. Test: Subtraction and Multiplication (SM)

[x]Factor O:	Originality The ability to produce remotely associated, clever, or uncommon responses. Test: Symbol Production (SP)
[x]Factor P:	Perceptual Speed Speed in finding figures, making comparisons, and carrying out other very simple tasks involving visual perception. Test: Number Comparison (NC)
[x]Factor R:	General Reasoning The ability to solve a broad range of reasoning problems including those of a mathematical nature. Test: Ship Destination (ShD)
[x]Factor Rs:	Syllogistic Reasoning The ability to reason from stated premises to their necessary conclusions. Test: Inference (Inf)
[x]Factor S:	Spatial Orientation The ability to perceive spatial patterns or to maintain orientation with respect to objects in space. This factor seems to involve perception of the position and configuration of objects in space, perhaps best thought of as space with the observer himself as a reference point. These tests were given under speeded conditions. Test: Cube Comparison (CC)
[x]Factor V:	Verbal Comprehension The ability to understand the English language. Test: Wide Range Vocabulary (WRV)
[x]Factor Vz:	Visualization The ability to manipulate or transform the image of spatial patterns into other visual arrangements. In this factor, the observer seems removed from the stimulus pattern in that he appears to manipulate and alter its image. Test: Surface Development (SuD)

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x indicates factor measured in one or more curriculum